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THE COAL INDUSTRY IN CANADA

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled THE COAL INDUSTRY IN CANADA submitted by Gerrit C. Van Kooten in partial fulfilment of the requirements for the degree of Master of Arts.

ABSTRACT

Because coal is Canada's most abundant fossil fuel, many feel that it will provide the solution to the energy shortages of the mid-1970's. However, there are several factors which may prevent coal from becoming the most dominant fuel. First, the convenience and efficiency factors which resulted in the erosion of the traditional coal markets (railroads and space heating) by other fuels still exist today. Second, economic and social problems related to the extraction and use of coal may be difficult to overcome in a society which is becoming more environment conscious. Finally, many technical difficulties remain to be solved in developing new markets for coal. At present coal is used only for metallurgical purposes and for thermal electric power generation.

Although coal output by the Canadian coal industry has increased rapidly in the last five years, the industry has been characterized by government aid in the form of subventions and other subsidies or nationalization. Over the past decade the emphasis of the Canadian coal output has shifted from the Maritime region ot the Mountain region, which exports coking coal, and the Prairie region, which sells its output to the power generating industry. The

Canadian industry is characterized by increasing concentration, economies of scale, and a gradual shift towards surface mining techniques. However, the future of the Canadian coal industry is uncertain because of changing technology and a turbulent world energy scene.

PREFACE

While I was working as a research assistant for the Province of Alberta's Grande Cache Commission in the summer of 1973, I became interested in the Canadian coal industry and the entire energy issue. During the 1973-74 school term I wrote several papers which were related to the coal industry. Although this thesis is based mainly on an industrial organzation paper, my committee members felt that I should include an econometric paper as a separate entity. This I did in Appendix A. This thesis also shows the influence of a paper dealing with some conceptual problems in determining the costs and benefits associated with coal mining. A list of some of the publications used in these papers is contained within the bibliography.

I realize that many of the predictions in this treatise will be outdated within several months. The reason for this is that the data and publications I had available to me were not as recent as one might have liked. (The most recent data was almost two years old although some articles were dated mid-1973). Changing energy technologies, new reserve discoveries, environmental pressure, and other economic or social factors requires on to use up-to-date information at all times. I would like to apologize for not having, or being able to provide, such information.

ACKNOWLEDGMENT

I would like to thank several people for their helpful comments made during the preparation of this thesis. Dr. F. Roseman's comments in the initial stages of this work were particularly helpful as were the comments of all my professors in the Department of Economics at the University of Alberta. I am grateful to Dr. T. Powrie for his comments as my thesis advisor and to Professors M. Stewart and G. Mumey for taking time to read this treatise. I am also indebted to Professor T.H. Patching of the University's Department of Mining Engineering and Mr. K. Wardell, a British mining consultant for enabling me to grasp the technical and reserve problems associated with coal mining.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

CHAPTER I

INTRODUCTION

To my knowledge, no work exists which has been written with the aim of providing a general overview of the entire Canadian coal mining industry and describing the role of coal in the energy field. It is the purpose of this treatise to furnish the background which is required in order to consider coal, as an energy source, in its proper perspective within the present-day energy issue. Although intended to provide the layman with an insight into the Canadian coal industry and the role of coal in the Canadian economy, the paper may provide useful background information for energy and resource economists as well as other energy specialists.

In this paper the descriptive, or quantitative, approach will be used to analyze the Canadian coal industry. This is in contrast to the approach used by James M. Henderson in analyzing the United States coal industry.[1] Henderson uses a linear programming model to show that the behavior of

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1 Henderson, James M. The Efficiency of the Coal Industry. Cambridge, Massachusetts: Harvard University Press, 1958.

the United States' coal industry deviated from the perfectly competitive norm. Using the perfectly competitive industry as a norm for an efficient industry, Henderson concluded that the U.S. coal industry was inefficient. On that basis he set forth some policy quidelines for the government to follow. But there is "no way of knowing whether his results are valid or to what degree they are invalid within his framework and, therefore, ... any conclusions of policy nature are simply unjustified."[2] Henderson fails to take into account elements which cause the industry to be inefficient or to deviate from the competitive norm. The quantitative hypothesis does explain the behavior of the industry by taking into account these elements and, therefore, "one could obtain a quantitative notion of how much total costs of production and distribution would be reduced if such-and-such a policy were put into effect."[3]

Whereas Henderson's linear programming model cannot take into account unforeseen technological and other changes because of the built-in, mathematical-type assumptions, the descriptive approach can, and does, take into account changing technologies, changing industrial organization, and changes such as those occurring in the legal and judicial areas. Hence the justification of a descriptive approach.

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2 Nerlove, Marc. "On the Efficiency of the Coal Industry", <u>The Journal of Business</u>. July, 1959, p. 277.

3 Ibid.

CHAPTER II

TECHNICAL ASPECTS

It is necessary to provide a technical base before one is able to proceed with the analysis. The types of coal, their chemical and physical properties, and their major uses are discussed in this section. Also included is a description of the various mining techniques and a description of the location of the coal resources of Canada as well as their quantitative estimates. Although the discussion of coal reserves could be included in the chapter on supply, it is included in this section because it provides the background necessary for the discussion of demand and also gives insight into the basic geographical divisions of the Canadian coal industry.

Coal: Properties, Classifications and Uses

What is coal?

> Coal is a mineral fuel of vegetable origin. It has formed from the cellulose, lignin and resin constituents of vascular swamp vegetation after millions of years of burial during which many chemical and physical changes have taken place. The degree of maturity of coal is related to the extent of these changes. Chemically, coals consist of various proportions of carbon, hydrogen, oxygen, nitrogen, and impurities. The carbon in coal occurs as fixed carbon and

in volatile matter. The percentage of fixed carbon on a dry basis determines the rank of coals when more than 69 per cent of fixed carbon is present; for lower ranked coals, classification is based on the b.t.u. content on the moist (as mined) basis. The classification of coal by rank permits its designation as anthracite, bituminous, subbituminous and lignitic, with further groupings under each of these main classes. This and other coal classifications provide a means of describing coal which, as a result of the varying conditions relating to its origin, has a wide diversity of characteristics.[4]

Coal is analyzed on the basis of four criteria:[5]

(1) water content (moisture);

(2) mineral impurity (ash) left when coal is completely burned;

(3) volatile matter which consists of the gases driven out when coal is heated; and

(4) fixed carbon.

The fixed carbon is a coke-like residue which, after the volatile matter has been driven off, burns at high temperatures. These criteria are used to differentiate among the four classifications (ranks) of coal and also to provide a basis for further groupings. "The classification of coals by rank is based on the percentage of fixed carbon and calorific value (expressed in b.t.u. per pound) calculated on the mineral

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4 Mineral Resources Division, Department of Mines and Technical Surveys. Minerals -- Canada and The World. Mines Branch Report No. 860. Queen's Printer, Ottawa: 1957. (Pages not numbered)

5 Schlick, Donald P. and N. L. Fannick. "Coal in the United States", Pulmonary Reactions to Coal Dust: A Review of U.S. Experience. (Marcus M. Key, L. E. Kerr and M. Bundy; editors). Academic Press, New York: 1971. p. 14.

matter free basis."[6] Table 1 presents the breakdown of coal into classes based on the per cent of fixed carbon and volatile matter, calorific content, and specific gravity.

Based on specific gravity anthracite is the hardest coal mined, but its heat content is less than that of some of the softer coals. According to the American Society for Testing and Materials (A.S.T.M.) classifications, anthracite has the highest per cent of fixed carbon -- 86 per cent or more. It is considered to be a specialty coal and is used in the iron and steel industries and in the chemical industry.[7] Very little anthracite is found in Canada although one mine in Alberta, the only province in which anthracite is known to occur, does produce some semianthracite.[8]

Bituminous coal is the second hardest coal and also the most abundant and widely used. Three sub-groupings, namely low-, medium- and high-volatile bituminous coal, occur within this rank as shown in Table 1. Bituminous coal is made into coke for use by the iron and steel industries, is used in the chemical industry, is used as a space-heating

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6 Latour, B. A. and L. P. Chrismas. Preliminary Estimate of Measured Coal Reserves Including Reassessment of Indicated and Inferred Resources in Western Canada. Geological Survey of Canada; Department of Energy, Mines and Resources. Queen's Printer, Ottawa: 1970. p. 3.

7 Chrismas, L. P. "Coal and Coke", Canadian Minerals Yearbook. Report No. 13. Mineral Resources Branch; Department of Energy, Mines and Resources. Queen's Printer, Ottawa: 1972. p. 7.

8 Only the Canmore Mines Limited produces some semianthracite for export to Japan. This coal is used by the Japanese for making steel.

TABLE 1

Summarized A.S.T.M.* Classification of Coals by Rank and Specific Gravity

Class Group	Fixed Carbon** (per cent) Equal or Greater Than	Fixed Carbon** (per cent) Less Than	Volatile Matter** (per cent) Greater Than	Volatile Matter** (per cent) Equal or Less Than	Calorific Value** per lb. (b.t.u.) Equal or Greater Than	Calorific Value** per lb. (b.t.u.) Less Than	Specific Gravity
Anthracite	86			14			1.47
Bituminous							1.32
Low-volatile	78	86	14	22			
Medium-volatile	69	78	22	31			
High-volatile		69	31		10,500	14,000	
Subbituminous					8,300	10,500	1.30
Lignite					6,300	8,300	1.29

* A.S.T.M.: American Society for Testing and Materials

** Dry, Mineral-Matter Free Basis

Source: Latour, B.A. and L. L. Chrismas. Preliminary Estimate of Measured Coal Reserves Including Reassessment of Indicated and Inferred Resources in Western Canada. p. 4.

fuel, and is used as a fuel for thermal electric power generation.[9] The low- and medium-volatile bituminous coals are better suited for coke-making than the high-volatile variety. The latter tends to be used mainly in the electrical generating industry although high-volatile bituminous coal can be used for coke-making.

Subbituminous coal and lignite are the softest coals with lignite being the softer of the two. Both varieties are steam coals and are used in the production of electricity and of heat for industrial and domestic buildings. Lignite is also used in making briquettes.[10]

Reserves of Canadian Coal

The 12th International Geological Congress of 1913 estimated Canadian coal reserves at about 1,217 billion metric tons -- about 16½ per cent of the world total. In 1947 Dr. B. R. MacKay estimated Canadian reserves at 94½ billion tons of which he considered 47½ billion tons to be recoverable.[11] Although these estimates are outdated and

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9 Chrismas, L.P. "Coal and Coke", Canadian Minerals Yearbook. Op. cit., 1972. p.7.

10 Ibid.

11 Three different types of measure for the ton exist. The relationship of each to the standard British pound (lb.) is as follows:
short ton = 2,000 lb.
long ton = 2,240 lb.
metric ton = 2,000 kg. = 2,200lb.
Unless specified differently, we will use the term ton to refer to a short ton.

inaccurate, they do tell us that coal is our most dominant form of energy if we ignore nuclear energy and future developments such as tidal and solar energy. Excluding the tar sands, coal represents 96.6 per cent of the thermal equivalent fuel reserves in Canada as opposed to 1.6 per cent and 1.8 per cent for petroleum and natural gas, respectively. [12]

Before considering the more recent estimates of Canada's coal resources it is helpful to identify the location of the main Canadian coal basins. Geographically Canada's coal deposits are located in two major areas, the Maritimes and the West. In the Maritimes six different coal fields can be distinguished although one is not being mined at the present.[13] The coal in these fields is of a medium-

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12 Burchell, D. G., et al. "Underground Coal Mining in Canada", Mining in Canada. 6th Commonwealth Mining and Metallurgical Congress. pp. 537-38.

13 The coal basins of the Maritimes are the following:
(a) Sydney field on Cape Breton Island;
(b) West-coast (Inverness) basin of Cape Breton Island;
(c) Pictou field in Nova Scotia near the New Brunswick border;
(d) Cumberland field in Nova Scotia near the New Brunswick border;
(e) Minto field in New Brunswick; and
(f) St. Georges in Newfoundland which is not being mined.

to high-volatile bituminous variety and the deposits are the oldest deposits known in Canada -- deposits of the Carboniferous period. The deepest mines in Canada are found in the Cumberland field of Nova Scotia where the subterranean workings reach depths of over 4,000 feet. The mines of Cape Breton Island constitute the largest undersea workings in the world with some coal faces as far as five or six miles from shore.

Although some lignitic coal reserves are found in the Hudson Bay lowlands in northern Ontario (Onakawana field), the major proportion of the Canadian reserves lie in the three western provinces -- Saskatchewan, Alberta and British Columbia. The quality of coal (as determined by hardness) increases as one moves westward from Saskatchewan to the western edge of the Rocky Mountains due to the increased maturity of the deposits and the shape of the geosyncline, which subjected the more westerly coals to greater pressure. Four main coal areas can be distinguished in this region.

(1) The coal of southern Saskatchewan (Souris Valley area) is all of the lignitic variety and Early Tertiary in age.

(2) The coal of the Plains area of Alberta varies from a high-volatile bituminous variety in the south (Lethbridge area) to a subbituminous type in all the other mining

basins of the Plains area.[14] The coals were formed in the Late Cretaceous period.

(3) The coal in the Outer Foothills Belt is all high-volatile bituminous in rank and is Late Cretaceous and Early Tertiary in age.

> Because of their proximity to the mountains the coal deposits in this belt have been subjected, to a considerable degree, to the same forces that formed the mountains. Consequently, the seams may be at any attitude, or folded, or truncated by faults or otherwise structurally deformed.[15]

Very little coal is mined in this area and it is often convenient to consider this area as a part of the Mountain, or Inner Foothills, Belt.[16]

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14 Four major coal mining basins, or areas, producing subbituminous coal in Alberta can be distinguished:
(a) Brooks and Taber area;
(b) Drumheller, Sheerness and Carbon area;
(c) Castor, Ardley and Camrose area; and
(d) Edmonton, Tofield and Pembina.

15 Latour, B. A. "Coal Deposits of Western and Northern Canada", Proceedings: First Geological Conference on Western Canadian Coal. (G. B. Mellon, J. W. Kramers, and Erica J. Seagel; editors.) Research Council of Alberta, Edmonton: September 1962. p. 4.

16 Coalspur, which is now a type of ghost town, was built for the purpose of being a base for a coal mine operating in this Belt.

(4) The coal in the Mountain Belt is usually of a low- to medium-volatile bituminous rank and has a low sulphur content.

> Coals of excellent coking quality have been found at various localities throughout the belt, but certainly not all the coal is of this quality and there is no way of predicting those areas or seams most favourable for its occurrence. Within a given stratigraphic section containing several seams, the coking quality may vary from seam to seam and, indeed, within a seam.[17]

The coals tend to vary in age from Early Cretaceous to Late Jurassic. This coal area extends from the United States border in the south to the Peace River Valley in the north.

Although many occurrences of coal are known, five coal basins can be distinguished in the central areas of British Columbia; and two small basins are known to exist on Vancouver Island. The deposits of the south-central region of British Columbia are all Tertiary in age but vary in rank. The Tulameen coal is subbituminous to high-volatile bituminous; the Merritt-Nicola deposits are mainly high-volatile bituminous; and the Hat Creek coal is lignitic.[18] The lignite deposits of Hat Creek are very thick (about 2,000 feet thick although layers of clay occur within) and it is felt that

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17 Latour, B.A. "Coal Deposits of Western and Northern Canada". Op. cit.

18 Ibid., p. 5.

they can be mined to provide fuel for an on-site electric power plant. The deposits of the mid-central area (Telkwa and Bowron River) are ranked as medium- to high-volatile bituminous although those of Telkwa are older (Lower Cretaceous) than those of Bowron River (Tertiary).

Recent exploration activity has resulted in coal discoveries in northeastern British Columbia at Butler Ridge and Hasler Creek in what is now called the Peace River Coalfield. Although high-volatile bituminous coal was at one time mined on Vancouver Island (Comox and Nanaimo coalfields), the reserves remaining are insignificant. The Comox coalfield is considered to be mined out.

The extent of coal occurrences in northern Canada is not well known. Three potential mining areas exist in the Yukon Territory but only the Carmacks area is being mined to serve the local lead-zinc operations. The coals are Mesozoic to Tertiary in age. Three occurrences of coal with mining potential exist on the mainland of the Northwest Territory and coal from one of these has been used as a fuel at Aklavik. Subbituminous coal has been found on the Arctic Islands. In fact, "there are now a sufficient number of reliable reports of coal seams of mineable thickness to indicate that the Arctic Islands coal deposits are extensive."[19]

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19 Ibid., p. 8.

The most recent estimates of Canadian coal reserves were undertaken by Latour and Chrismas in the late 1960's. But

> only the coal resources of the three western provinces were studied as it is estimated that about 93 per cent of Canada's coal resources are in western Canada. The remaining 7 per cent is divided almost equally between Nova Scotia and the Northwest and Yukon Territories. Small deposits are also worked in New Brunswick and some coal of low rank occurs in Northern Ontario south of James Bay,[20]

but these are ignored in arriving at total Canadian estimates as are the deposits of Vancouver Island.[21] However, Coates estimated the Onakawana reserves as 0.2 billion tons of lignite and also included an estimate of 1 to 2 billion tons for the reserves of the Maritime provinces.[22]

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20 Chrismas, L. P. "Coal and Coke", Canadian Minerals Yearbook, 1970. Op. cit., p. 173.

21. Latour, B. A. "Coal Deposits of Western and Northern Canada". Op. cit., p. 5.

22 Coates, G. D. Canada's Fossil Fuel Resources. Luscar Ltd., 1973: p. 5.
Also see: Chrismas, L. P. and M. K. McMullen. Coking Coal in Canada. Mineral Resources Branch, Department of Energy, Mines and Resources: 1973, pp. 5-9.

In the Sydney area of Nova Scotia indicated and inferred coal reserves are estimated at 710,700,000 tons. However, since the seams dip seaward in most Nova Scotia coal basins, exact measurement is unknown. Ten million tons of coal are estimated to be recoverable by surface methods to a depth of 65 feet in New Brunswick.

Any discussion of energy resources is plagued with the problem of finding a suitable definition of reserves because any reserve figure is dependent on many variables including prices, technology and legal restraints. It was only recently that the U.S. Bureau of Mines and the U.S. Geological Survey were able to come to a mutual agreement regarding the definition of reserves.[23] Even so the definition is limited in application. For example, the definition does not allow for reserves of methane in coal beds to be included as an energy reserve. This was in spite of the fact that

> gas from a borehole in a virgin West Virginia coal bed is being fed into a commercial pipeline near Morgantown at rates of about three-quarters of a million cubic feet per day. This production rate is in excess of most Appalachia gas wells.[24]

Latour and Chrismas use a definition of coal reserves which is based on the spacing of observation, or control, points (outcrops, trenches, mine workings and drillholes), the thickness of the coal seams, and the depth at which the coal beds occur.

The estimates of coal resources fall into three categories.

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23 National Coal Association. "BoM, USGS Agree on Reserve Definition", Coal News. (No. 4209). Washington: April 19, 1974. p. 5.

24 Ibid.

(1) Measured, or proven, resources are

> those reserves of coal considered to be economically recoverable under present conditions and for which the tonnage is computed from measurements at control points spaced closely enough to provide a high degree of assurance that the amounts of coal so computed will actually be found in place.[25]

Although the necessary spacing varies from one area to the next, the points of observation generally tend to be about ½ mile apart. The computed tonnages are judged to be accurate within 20 per cent of the true tonnage.

(2) Probable, or indicated, coal reserves are

> defined as those reserves of coal, economically recoverable under present or foreseeable future conditions, which may reasonably be assumed to exist on the basis of available geological evidence.[26]

The estimates are computed from specific measurements and projections based on geological evidence, with control points generally 1 to 1½ miles apart.

(3) Possible, or inferred, resources are quantitative estimates based on a broad knowledge of the geological character of a particular area with observation points about 2 miles apart. A large degree of error is associated with these estimates.

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25 Gorrell, H. A., C. A. S. Bulmer and M. J. Brusset. "Monetary Evaluation of Coal Properties", Proceedings: First Geological Conference on Western Canadian Coal. (G. B. Mellon, et. al, editors). Research Council of Alberta, Edmonton: September 1962. p. 63.

26 Ibid.

Latour and Chrismas included in the measured category only those coal seams which were five feet or more in thickness. Furthermore, in the Mountain and Outer Foothill Belts, the seams could not be found more than 2,500 feet below the surface in order to be classified as proven; in the Prairie region (Alberta and Saskatchewan) the depth could not exceed 150 feet. Tables 2 and 3 provide a summary of the coal resources of western Canada by province and rank. The total reserves of the western provinces are estimated at 118.7 billion tons. Adding to this the estimates of Coates and ignoring the coal deposits of the North, Canadian reserves total about 121.3 billion tons.

Mining Methods

As background to the arguments which appear later, it is useful to present a description of the various mining techniques and some of the problems related to them. Two basic mining forms can be identified -- underground mining and surface, or strip, mining. We will deal with each separately.

(1) Underground Mining

Entry into a coal bed which cannot be mined by surface methods can be accomplished in several ways. A

TABLE 2

Coal Resources of Western Canada by Province

(thousands of short tons)

Province	Measured	Indicated	Inferred	Total
British Columbia	7,328,600	11,175,400	40,953,000	59,457,000
Alberta	2,203,900	32,096,100	12,940,200	47,240,200
Saskatchewan	291,500	7,024,000	4,698,400	12,013,900
Western Canada Total	9,824,000	50,295,500	58,591,600	118,711,100

Source: Latour, B. A. and L. P. Chrismas. Preliminary Estimate of Measured Coal Resources Including Reassessment of Indicated and Inferred Resources in Western Canada. p. 11.

TABLE 3

Coal Resources of Western Canada by Rank and Province

(thousands of short tons)

Province	Measured	Indicated	Inferred	Total
	Low- and Medium-Volatile Bituminous			
Alberta	982,100	19,620,200	7,366,500	27,968,800
British Columbia	6,943,000	10,775,000	40,480,100	58,198,100
Rank Total	7,925,100	30,395,200	47,846,600	86,166,900
	High-Volatile Bituminous			
Alberta		6,278,600	3,043,700	9,322,300
British Columbia	45,600	100,400	172,900	318,900
Rank Total	45,600	6,379,000	3,216,600	9,641,200
	Subbituminous			
Alberta	1,221,800	6,197,300	2,530,000	9,949,100
	Lignitic			
British Columbia	340,000	300,000	300,000	940,000
Saskatchewan	291,500	7,024,000	4,698,400	12,013,900
Rank Total	631,500	7,324,400	4,998,400	12,953,900
Grand Total	9,824,000	50,295,900	58,591,600	118,711,100

Source: Latour, B.A. and L. P. Chrismas. Preliminary Estimate of Measured Coal Resources Including Reassessment of Indicated and Inferred Resources In Western Canada. pp. 11-12.

vertical shaft can be driven down into the coal seam, after which the shafts are driven horizontally into the seam, or a horizontal shaft can be driven into the seam where the seam outcrops on the side of a mountain. Shafts are often driven into the coal beds at an angle to permit the movement of men, equipment and coal into or out of the mine without requiring a transfer from one form of transportation to another, which would be the case in a vertical shaft situation where men and equipment would have to transfer from rail cars to elevators or vice versa. Hence the horizontal or "angular" entrances are preferred to the vertical.

Most mines use belt conveyors for coal haulage and some type of equipment-man-materials access consisting of either free moving machines with rubber tires or track haulage equipment. The conveyors and vehicular form are accommodated in the mine shafts either double-deck or side-by-side as shown in Figure 1.[27] (Figure 1 also shows some of the shapes which underground roads, or shafts, can take.)

In developing an underground mine one must consider the direction of mining amongst other things.

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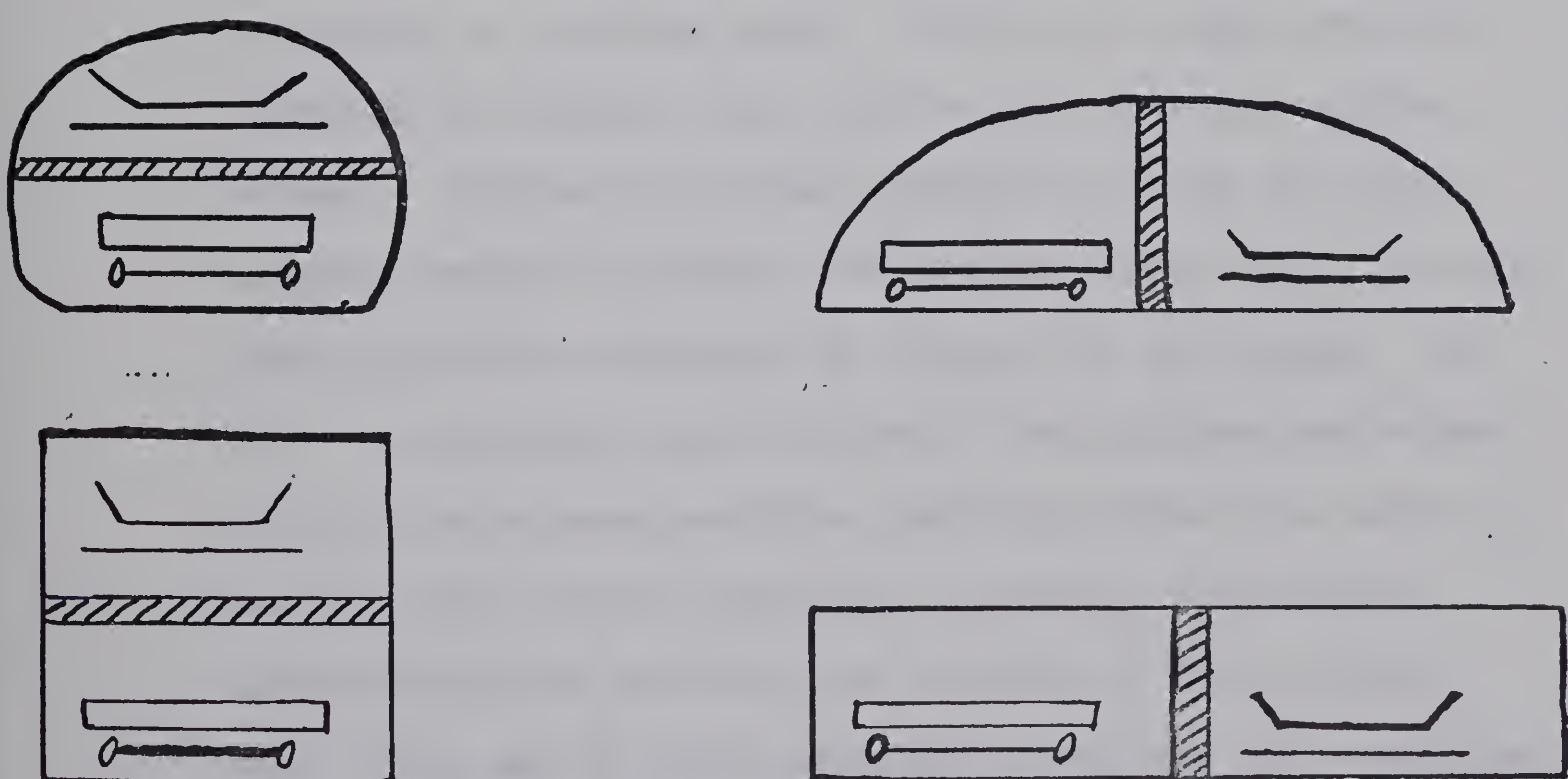
27 "Mining Guidebook", Coal Age: 1972 Mining Guidebook and Buying Directory. Volume 77, Number 7. McGraw-Hill, Inc., New York: July 1972. pp. 129-133.

> All things being equal, full-retreat mining, meaning mining from the boundary (of the coal seam or potential mining area) back, is the ideal system with exceptions so few as to be almost negligible. But more time is involved, even with the high speed possible with today's equipment, so combination advance and retreat has become a popular system. One side of the area, or even of the entire mine, is worked on the advance, providing quick coal at full rate and normal costs. The other side is worked on the retreat. [28]

FIGURE 1

Transportation Equipment Accommodation

In Underground Mines



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28 Ibid., p. 133. Words in brackets are my own.

In order to clarify these concepts one must look at two methods of underground mining.

(a) The room-and-pillar approach is the most common method used in the United States and accounts for more than 90 per cent of the total underground production.

> Room-and-pillar remains almost unchallenged as the basic working-section plan with conventional loaders or mobile-type continuous miners. Full retreat, and advance on one side and retreat on the other are the two most popular panel plans.[29]

Continuous miners cut the coal and load it onto conveyors at the same time. The conventional technique uses a mining machine which cuts the coal and a separate mechanical loader to load the coal onto conveyors or haulage cars. Pillars of coal are left standing to support the roof in the room-and-pillar method. Although circular pillars provide the best support, square pillars are the most practical because their relative strength is closest to the round. In order to maximize coal recovery the pillars are mined out on the retreat and the roof is allowed to cave in. Because this caving results in surface subsidence, legislation may prevent the removal of the pillars. Hence they may be left standing after the mine has been abandoned. Figure 2 shows how a mine might be developed

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29 Ibid., p. 136.

by the room-and-pillar method. In this case the coal pillars are removed on the retreat.

(b) The trend is towards increased use of the longwall method.

> The (longwall) method can be used in coal seams ranging in thickness from a low of around 22 in. to a high of 10 ft., with the majority between $3\frac{1}{2}$ and 5 ft., and in veins pitching up to 8 to 10 per cent. Face lengths range from 300 to 650 ft., with an occasional longer exception. Some shorter than 300 ft. are in operation or contemplated.[30]

Although conventional and continuous mining equipment is capable of rates of production which exceed those of longwall equipment and can be used in seams that pitch up to 20 degrees, the longwall approach has several advantages.

(i) As figure 3 shows, longwall equipment provides roof support next to the mining face by means of powered self-advancing supports.[31] Hence reasonable recovery of good coal can be obtained at extreme depths. This method of mining is also of use where the overburden is shallow and next-to-face roof support is required.

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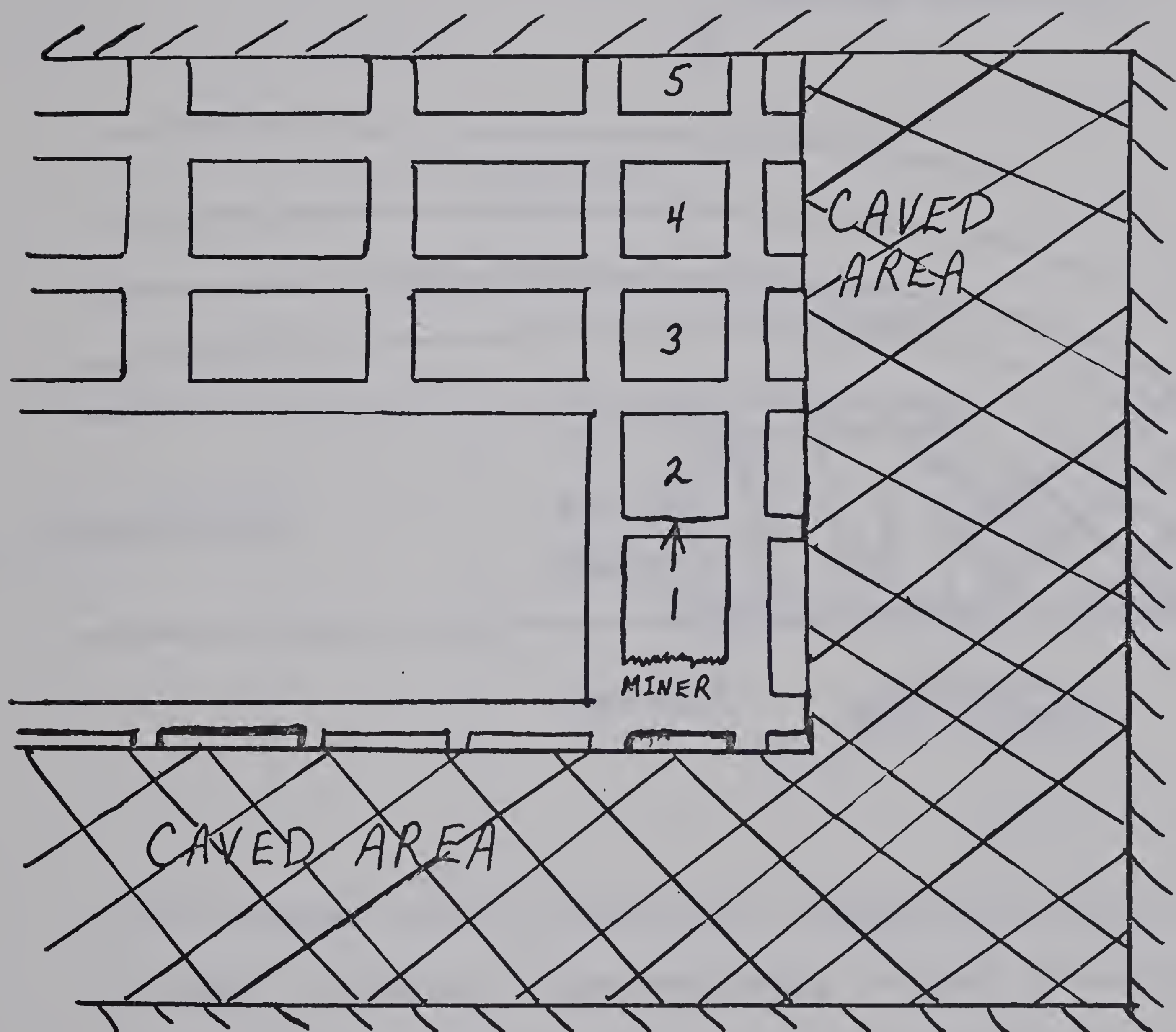
30 Ibid., p. 138.

31 I am grateful to Professor T. H. Patching for guiding me through the technical literature and for providing figures 3 to 5.

FIGURE 2

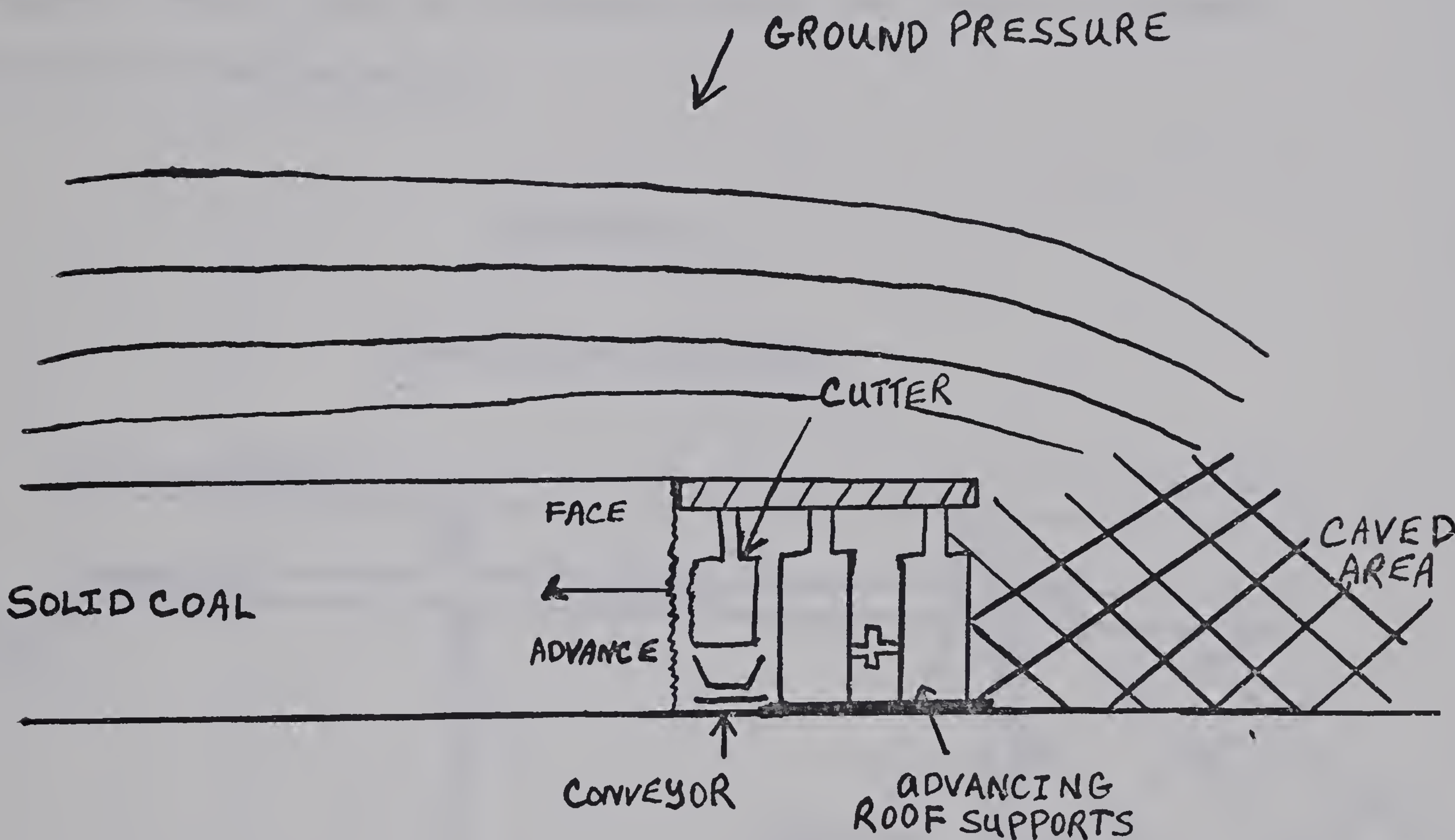
Room-and-Pillar Mining



Source: "Mining Guidebook", Coal Age: 1972 Mining Guidebook and Buying Directory. p. 135.

FIGURE 3

Next-to-Face Roof Support in Longwall Mining



(ii) Because of its flexibility longwall equipment can be used in shallow seams measuring between 32 and 42 inches high. Conventional and continuous miners cannot be used in such seams and there will be a greater shift to longwall as more seams of this height come into production in the future.

The retreat longwall approach (figure 4) is used more extensively in the U.S. than the advance approach (figure 5). The latter is used exclusively in Britain and on Cape Breton

Island. Recently, however, some companies in the United States have gone to the alternate advance in one panel and retreat in the next as shown in figure 6. The advance longwall method has an advantage over the retreat longwall method in two respects.

FIGURE 4

Retreating Longwall

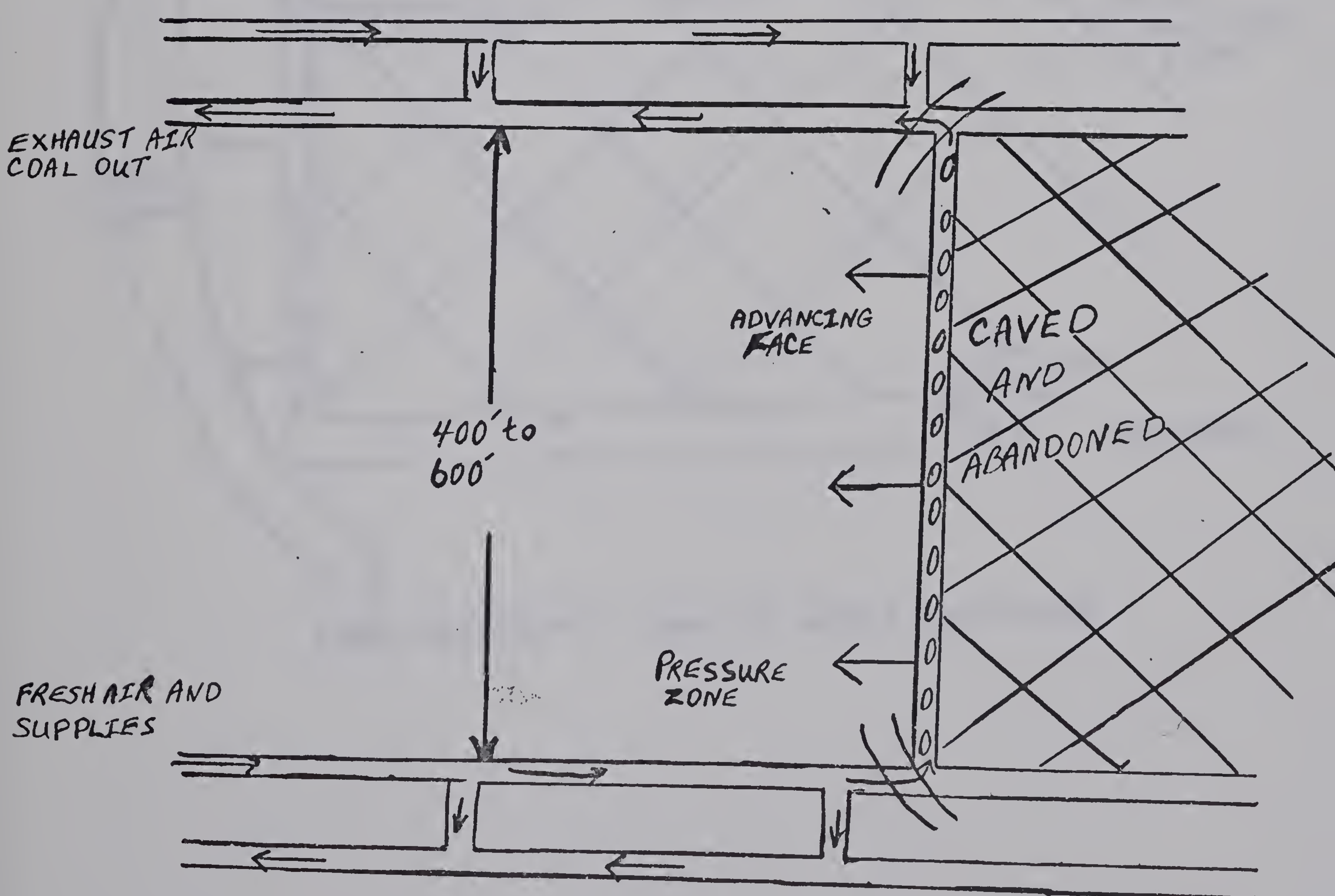


FIGURE 5

Advancing Longwall

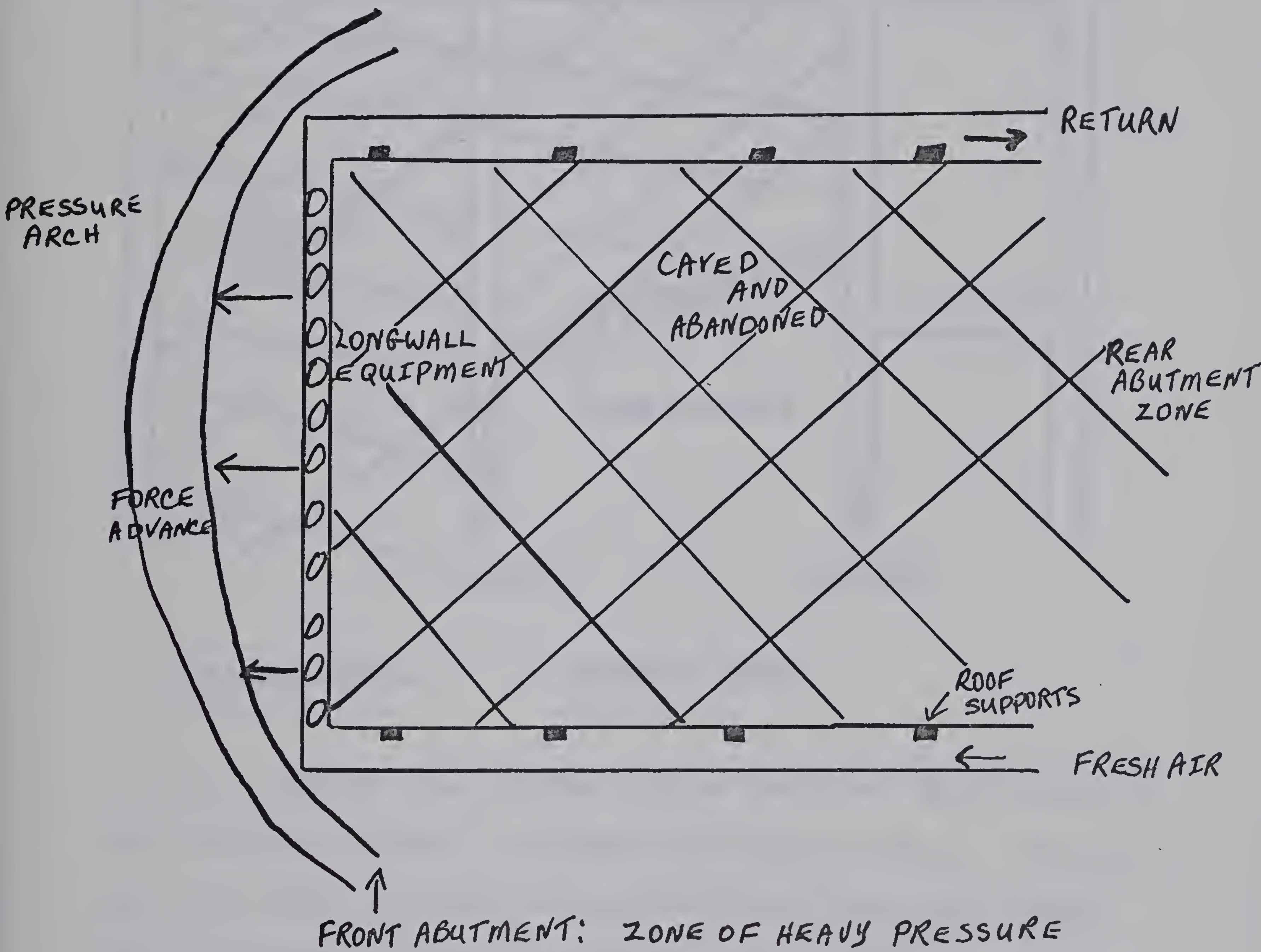
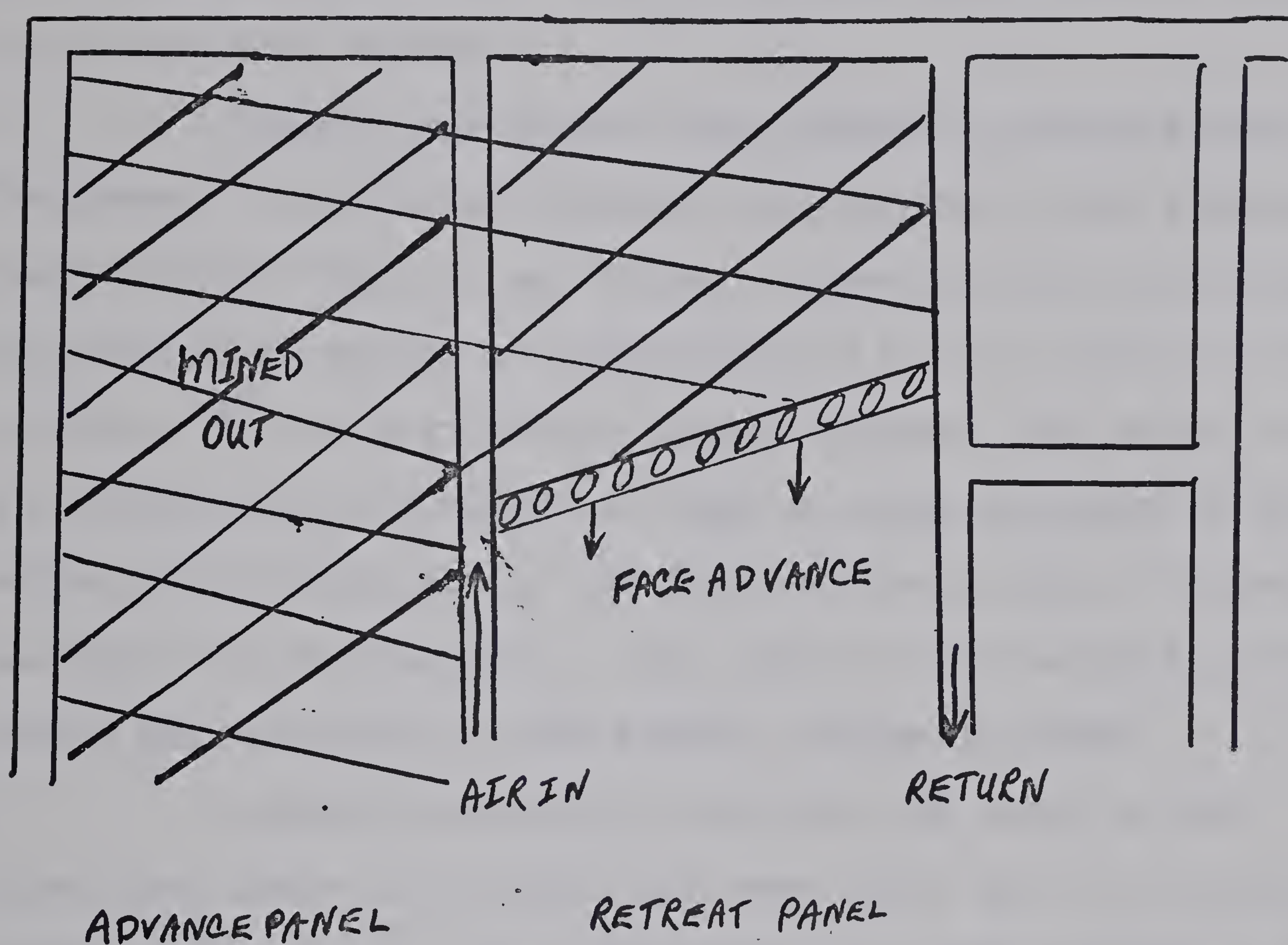


FIGURE 6

Alternate Advance and Retreat Longwall



First, the retreat method requires the driving of four shafts in order to create one longwall face. (This is only the case in establishing the first face since later faces can use the shafts of previous ones.) The reason for this number of shafts is ventilation although it also aids in the provision of transportation facilities. Every face, even the narrow faces which exist as the shafts are being built, must be well ventilated to reduce the hazards of explosions due to the presence of methane gas or coal dust.

The shafts are driven by equipment other than longwall equipment, i.e. by continuous miners or conventional cutters and mechanical loaders. Only longwall equipment is required in the advance method.

Second, any mining face creates a pressure arch. Whenever "a heading is advanced, the layers in the immediate roof deflect slightly and relieve themselves of the load of the overlying strata by transferring it to the sides of the opening."[32] In the retreat longwall method this means that extra pressure is brought to bear on those sections of the side shafts which lie in the front abutment zone of pressure as shown in the diagrams. This creates roof control problems which are not found in the advance longwall method.

Longwall mining is unsuitable in areas of the mine where some of the coal has been mined by the room-and-pillar technique.[33] Its effectiveness is also hindered by frequent moving of the equipment, faulting, pitching seams and variations in coal seam thickness.

Roof control is a particular problem associated with underground mining. Timbering, roof-bolting, steel

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32 "Mining Guidebook", op. cit., p. 147.

33 McIntyre Porcupine Mines Limited developed its No. 2 Mine at Smoky River, Alberta for longwall mining. However, in order to meet contractual commitments it mined certain sections by the room-and-pillar method although these sections were meant to be mined using the longwall equipment. Hence, much longwall equipment sat idle for long periods of time.

arches and rings, reinforced concrete linings, and powered self-advancing supports are some of the methods by which the roof can be supported although each adds considerably to mining costs. Because longwall equipment includes powered self-advancing supports, roof control is easier than in the room-and-pillar technique where separate crews are usually required for roof-bolting, timbering or the like since rooms usually have some degree of permanence.

Although it is beyond the scope of this paper, it is useful to note some of the externalities associated with underground coal mining. The external diseconomies of underground mining include the social costs of the early deaths of workers, disease ("black lung"), pollution (acid mine drainage), and the damage to buildings resulting from a subsidence of the surface.

(2). <u>Surface Mining</u>

Over the last two decades the emphasis in coal production has shifted from underground mining to surface mining. Whereas in 1962 about 40 per cent of coal production in Canada came from surface mines, in 1972 almost 80 per cent of total Canadian coal production came from stripping operations.[34] Surface mining is cheaper, safer, and more

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34 Statistics Canada. <u>Coal Mines</u>. Catalogue No. 26-206.

productive and capital intensive than underground mining. For example, average output per man-day in 1971 was 39.5 tons for Canadian surface mines (weighted average) but only 4.5 tons for underground mines.[35]

Strip mining involves the stripping of the soil, rock and other overburden lying above a coal seam so as to expose the coal and facilitate extraction. The amount of overburden which can economically be removed depends on a number of factors. The type of coal (and hence its price), the size of the coal seam, the terrain, and the alternative uses of the land all help to determine the feasibility of strip mining. Generally coal in flat lying areas can be strip mined if the overburden depth is less than 150 feet. In Canada's mountain areas the depth of the overburden should be less than in the flatter regions (about 100 feet or less of overburden) although there are exceptions to this.[36]

> It is estimated that about seven per cent of the measured coal resources in the (Alberta) Mountains and Foothills (982,100,000 short tons) can be mined by surface methods, whereas all the measured coal resources of the (Alberta) Plains (1,221,800,000 short tons) are potentially mineable by surface methods under present economic and technological conditions.[37]

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35 Ibid.

36 McIntyre Porcupine Mines Limited plans to strip mine a seam of coal which lies below 150 feet of overburden or more (No. 9 Mine).

37 Slaney, F. F. and Company Limited. Environmental Impact of Surface Coal Mining Operations in Alberta. Vancouver: 1971. (A Report for the Environmental Conservation Authority of Alberta: Edmonton.) p. 5.

All the measured lignitic coal resources of Saskatchewan (291,500 tons) and British Columbia (340,000 tons) are also potentially mineable by surface methods. Assuming similar conditions in the mountains of British Columbia as in Alberta, an estimated 7 per cent of British Columbia's measured Mountain reserves (6,943,000,000 tons) can be strip mined.

Drilling equipment is used by mining companies to drill holes in which explosives are placed. The explosives aid in breaking up the overburden which is then cleared by wheel loaders, bulldozers or draglines. Figure 7 shows how each type of equipment handles the overburden.[38] Once the coal has been exposed front-end loaders, back-end loaders or draglines can be used to load the coal onto trucks (ranging in capacity from 10 tons to over 100 tons) or railway cars. The ability to use so many different sizes of equipment results in a large variance in the size of strip mining operations.

Surface mining in flat-lying areas is much simpler than strip mining in the mountains or foothills. In the flat-lying regions an initial cut is made to remove the overburden. This cut lies on one side of the mining area and runs in the same direction as the coal seam. The

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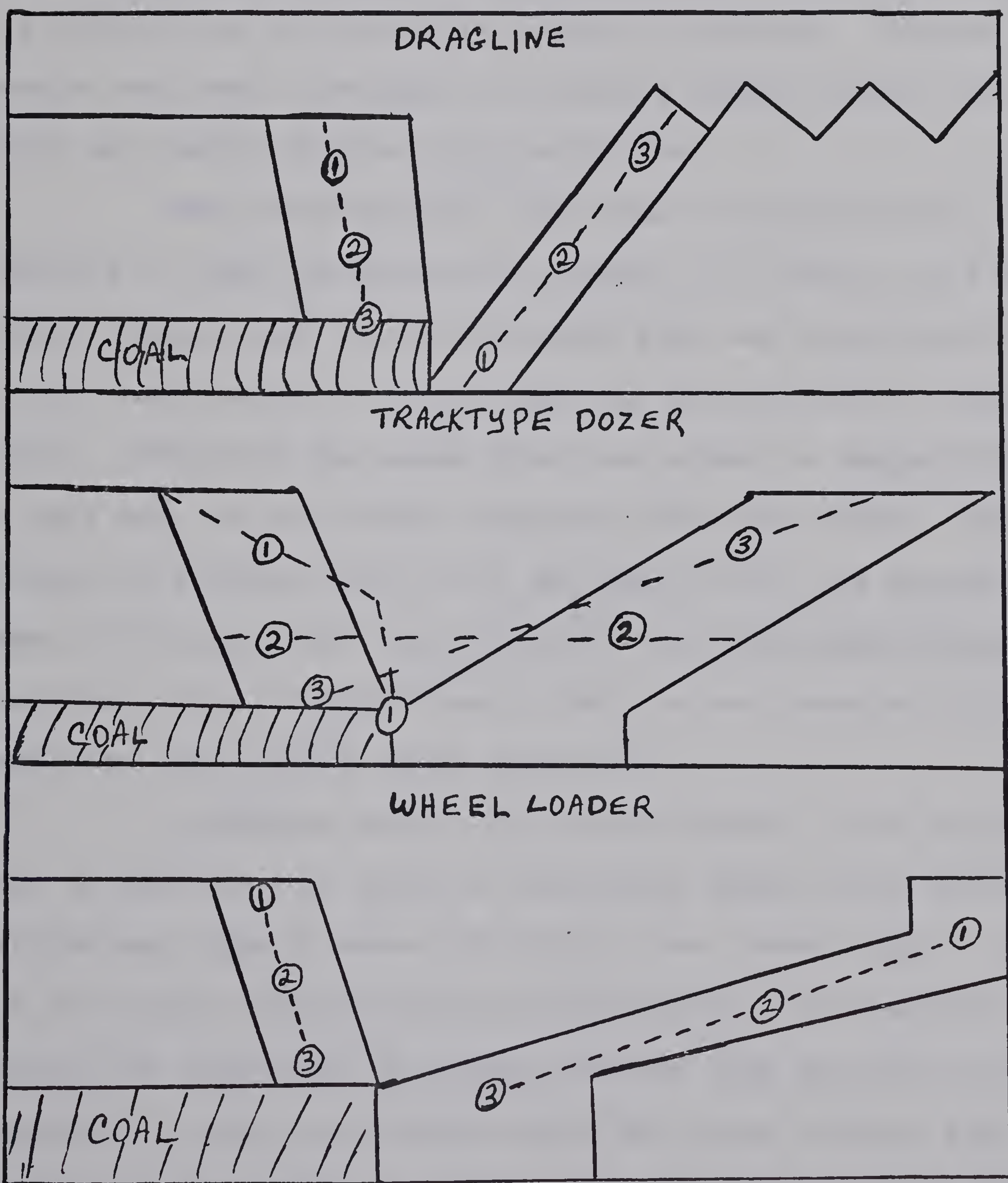
38 "Mining Guidebook", op. cit., p. 174.

FIGURE 7

How Dragline, Dozer and Front-end Loader

Move Overburden

(Numbers Show Steps)



overburden from this initial cut, or trench, is deposited on the outskirts of the mining area. When the coal has been removed from this first trench, a second cut is made parallel to the first with the overburden of this second trench deposited in the first. This operation is continued until the boundary of the mineable region is reached. Furrows and mounds are found throughout the entire mining region but these are easily leveled by a bulldozer.

When more than one coal seam is present and it is feasible to mine the second (or third, ...) seam, the first trench remains open after the upper seam has been mined. Further overburden is removed and the second seam is also mined. After all the seams have been mined, a second trench is made and the overburden deposited into the first. The process is repeated until all the coal in all the mineable seams of the area has been removed. In some cases mining is feasible only if there is more than one coal seam and the seams are not too far apart vertically.

In regions with very uneven terrain, coal outcrops tend to occur on the sides of mountains rather than in the valleys and this is where the mining then takes place. Open-pit or contour surface mining is practiced. In open-pit mining the overburden is simply removed from the side of a mountain, or hill, and thrown down the slope thereby disturbing an area which is larger than the actual mining area. As figure 8 shows, stripping starts near the outcrop by cutting

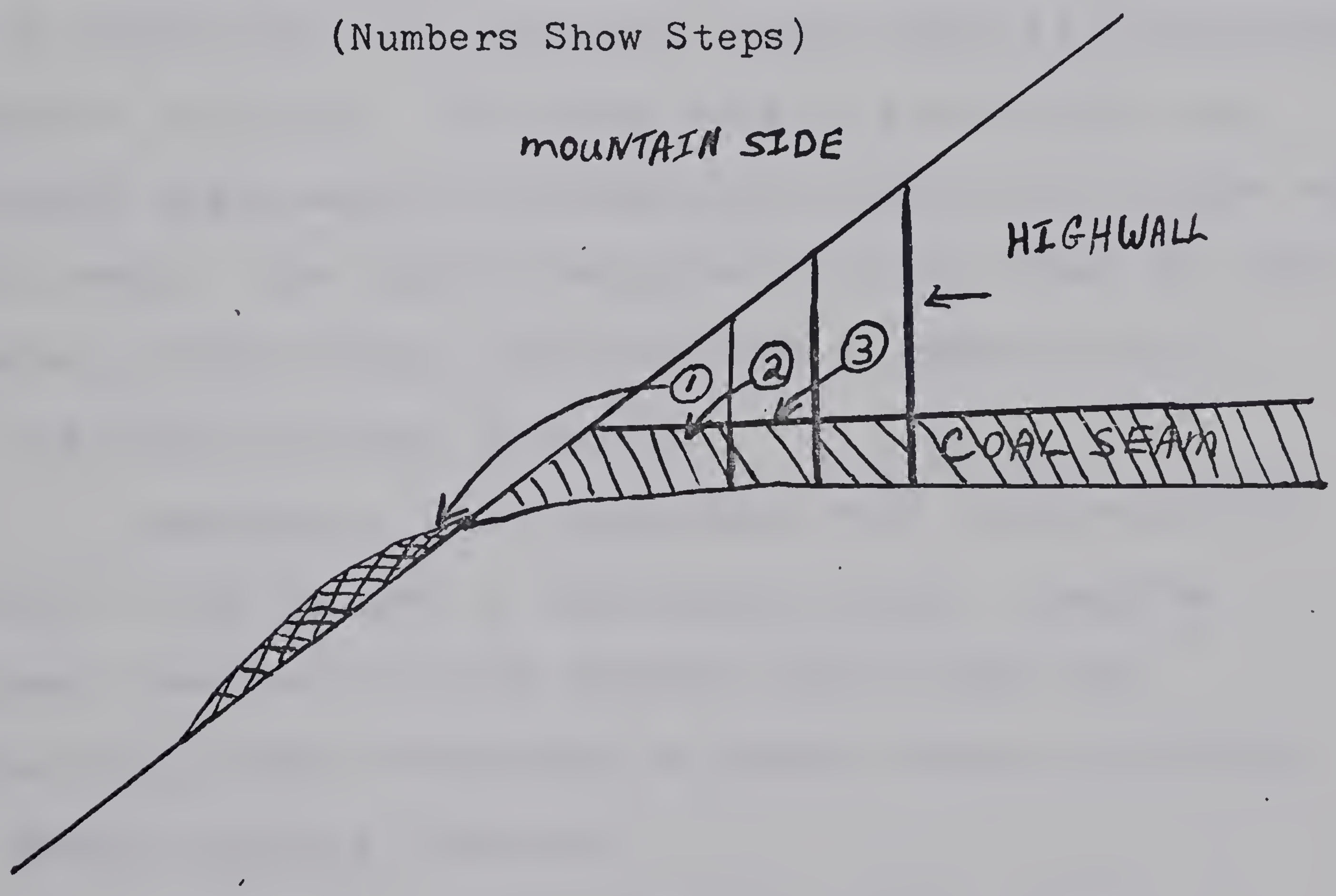
a trench and casting the overburden down the slope.

> After coal is mined from this cut, another strip of coal adjacent to the first cut and on the down dip side, is similarly exposed. Overburden from this second strip is placed in the space created by the removal of the first cut. This process repeats (itself) until overburden depth becomes so great that mining is no longer economically feasible. [39]

FIGURE 8

Surface Mining in Rugged Terrain

(Numbers Show Steps)



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39 Ibid., p. 177.

Contour mining is very similar but, as its name implies, the various trenches occur in a circular fashion as the mining equipment proceeds all the way around an uplifted area. In this case the coal seam usually underlies the entire uplifted area (or mountain).

The presence of multiple seams is handled much the same as in flat-lying areas except that the mining begins at the outcrop of the bottom seam. As one moves up the side of the mountain the upper seams come into production but the overburden lying above the lower seams increases. The bottom seam is mined until the overburden ratio makes it economically infeasible to do so. The entire area is mined until the overburden depth makes it economically infeasible to mine any of the seams. Once again the presence of more than one seam may make surface mining feasible where it might not be if only one seam was known to exist.

Augering is often associated with surface mining although it can be used in underground mines. Augering equipment removes coal from exposed seams, which are covered by too much overburden to permit further stripping, by a simple drilling technique.

> Coal produced by augering usually is dry, clean and has a high proportion of lump sizes.... Augers are available in diameters ranging from 16 to 84 in., and are capable of producing as much as 25½ tons of coal per minute.... The

> depth to which augering is carried out depends to a great extent on the coal thickness, whether the seams roll or are flat, and whether they are strong enough to stand after penetration and not foul the auger. Distance between holes also depends on the strength of the coal and the overlying rock.[40]

In Canada little coal is produced by augering because augering is best suited to use in mined-out surface mines located in rugged terrain. (The highwall auger is the most productive.) Since the strip mines in Canada's Mountain Belt are relatively new, augering has not been necessary yet.

Acid mine drainage and the social costs of land damage are the major externality costs associated with strip mining. The external diseconomy resulting from land damage may take a variety of forms. It may be that land damage destroys recreational areas or the output ability of an agricultural area. Perhaps the loss of scenic amenities is the largest social cost associated with strip mining especially in mountainous regions.

In Canada all of the above mentioned forms of mining are practiced. The mines of Nova Scotia are all underground mines and tend to use the longwall method of mining more so than room-and-pillar. In the Mountain regions of Alberta and British Columbia some underground mining is practiced although most of the output of this area is from surface

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40 Ibid., p. 181.

mines.[41] Although room-and-pillar mining is the basic underground method used, some longwall mining has been tried. The Prairie regions of Alberta and Saskatchewan produce coal by surface techniques although an insignificant amount of the Alberta output is from room-and-pillar underground methods. Coal in New Brunswick is produced by stripping methods only.

Before proceeding to consider some of the other aspects of supply, it is helpful to consider the demand aspects first. In order for one to fully understand the changes which have taken place on the supply side it is necessary to consider the changes in demand.

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41 Each underground producer also operates a surface mine.

CHAPTER III

THE DEMAND FOR COAL

The coal mining industry in Canada, as well as that of the United States and Europe, has been faced with a highly unstable demand. During World War II and shortly thereafter demand for coal increased very rapidly. U.S. production reached its highest level (630 million tons) in 1947.[42] Canadian production peaked three years later when 19.1 million tons of coal were produced.[43] Since then, and into the mid-1960's, the industry as a whole was faced with rapidly declining demand. Not only had a greater efficiency in the use of coal resulted in less demand but interfuel competition has eroded many of the markets previously held by coal.[44]

In this section the changing demand for coal since World War II and the impact of interfuel competition will be

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42 Sorenson, Glenn E. "Bituminous Coal Economics", Readings in Economic Geography. (Howard G. Roepke and Thomas J. Maresh, editors.) John Wiley and Sons, Inc., New York: 1967. pp. 332-336.

43 Statistics Canada. General Review of the Mineral Industries. Catalogue No. 26-201.

44 Moyer, Reed. Competition in the Midwestern Coal Industry. Harvard University Press; Cambridge, Massachusetts: 1964. pp. 47-8.

considered. Further, the present day markets for coal will be analyzed and a discussion of potential markets will be presented.

Historical Changes in Demand and Interfuel Competition

The railways and space heating agents have traditionally been the largest consumers of coal. In 1951 the Canadian National Railway Company set about to convert all its steam locomotives, which used coal to heat the boilers, into diesel locomotives because the latter were more efficient and cheaper to operate. In 1953 Canadian Pacific followed suit. This changeover from coal to fuel oil by the railroads, as depicted in Table 4, was a big blow to the coal industry.

Table 5 depicts a similar trend in the space heating market. Because coal was dirty, difficult to handle, relatively expensive, and required space for storage, consumers disliked using it as a space heater. The advent of natural gas and home heating oil (where natural gas was not available or competitive) and the ease with which these could be used to heat homes and office buildings facilitated their replacement of coal as the dominant fuel for space heating.

TABLE 4

Estimated Heat Equivalent Oil Used by Locomotives as a Percentage of Total Coal and Oil, 1943-62

Year	Per Cent	Year	Per Cent
1943	4.3	1953	20.2
1944	4.4	1954	25.2
1945	4.2	1955	31.9
1946	4.6	1956	35.2
1947	4.6	1957	46.3
1948	5.0	1958	65.6
1949	7.7	1959	83.1
1950	12.4	1960	96.9
1951	14.5	1961	99.5
1952	16.9	1962	99.5

Source: "Coal and Coke", Canadian Minerals Yearbook

TABLE 5

Consumption of Coal and Coke for Household and Commercial Building Heating, 1947-67

(thousands of short tons)

Year	Consumption	Year	Consumption	Year	Consumption
1947	13,117	1954	8,600	1961	4,111
1948	13,429	1955	8,283	1962	3,615
1949	12,473	1956	8,049	1963	3,056
1950	12,653	1957	6,953	1964	2,651
1951	11,437	1958	6,062	1965	2,062
1952	10,515	1959	5,751	1966	1,734
1953	8,941	1960	4,717	1967	1,349

Source: "Coal and Coke", Canadian Minerals Yearbook

The switch from coal to other types of fuel was made for reasons other than just costs as the above indicates.[45] Convenience and efficiency of the other fuels resulted in the decreased usage of coal. For example, "in the postwar period, both coal and distillate fuel prices increased

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45 In some instances costs did of course play a big role. The City of Edmonton found it cheaper to use natural gas in its power generating plants as did Calgary Power Limited at Wabamun. (See Paproski, Dennis M. The Demand for Coal by the Electrical Generation Industry in Alberta. M.A. Thesis, The University of Alberta: 1967.)

sharply but at approximately the same rates; still, coal consumption dropped 3.6 per cent annually while fuel use increased 12.8 per cent yearly."[46] Table 6 shows that the cost of coal was consistently lower than that of other fuels on a b.t.u. basis available to the thermal electric power generating industry. Although other factors must be considered, it seems that all consumers could get cheaper fuel on a b.t.u. basis by switching to coal.[47] But the trend was to substitute against coal.

TABLE 6

Average Fossil-Fuel Costs "as Burned" for Electric Utility Steam-Electric Generation in the U.S.

	1960	1965	1968	1969	1970
Coal	26.0¢	24.4¢	25.5¢	26.6¢	31.1¢
Oil	34.5	33.1	32.8	31.9	36.6
Gas	23.8	25.0	25.1	25.4	27.0

Although Table 6 indicates that coal is cheap on a b.t.u. basis relative to other fuels, high costs of transporting the coal (relative to the costs of transporting

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46 Moyer, Reed. Op. cit., p. 49. (See also Hendry, James B. "The Bituminous Coal Industry", The Structure of American Industry. Walter Adams, editor. 3d edition.)

47 See Appendix A.

natural gas) have forced electric power companies to locate their generating plants near, or at, the coal minesites or to use a fuel other than coal. Only through the changes in transportation technology, in particular the building of extra high voltage (EHV) transmission lines, has coal become more competitive with other fuels in the generation of electricity. Railroads have been forced to innovate (in order to capture some of the coal freight) as a result of interfuel competition and the threat of competition from other forms of transportation.[48] Technological and innovative changes, such as the introduction of unit trains, can be expected to cut transportation rates per ton of coal by significant amounts thereby making coal more competitive.

Transformation of coal from one energy form to another will also increase its competitiveness. Coal gasification and liquefaction, both of which are discussed further below, will aid in reducing the high costs of coal transportation much as the extra high voltage transmission lines have done. If gasification techniques are perfected, coal gas will be as easy to handle and as clean burning as natural gas. Coal gasification and liquefaction will both result in coal becoming more competitive with other fuels.

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48 The form of transportation considered to be the most important competitor of the railways is the coal slurry pipeline.

In the late 1960's and early 1970's the demand for coal began to increase again. This resurgence is due to the increased demand for coal by the thermal electric power generation industry, the increased demand for coking coal and the so-called "energy crisis" which has resulted in higher prices of the major fuels which compete with coal. Leaving aside the rapid increase in the prices of other fuels with which coal competes, we now look at the demands for Canadian coal by the electric generating industry and the steel industry.

Demand for Coal by the Electric Power Generating Industry

The demand for coal by the thermal electric power generating industry is expected to increase in the near future as the industrial, commercial and residential demand for electricity increases. But will the demand for coal increase in direct proportion to an increase in the demand for electricity or will it increase faster or slower than the demand for electricity? To answer this question one must look at the prices of competing fuels, competing methods of generating electricity, advances in technology and legal requirements, if any.

Various methods of generating electricity compete with the conventional steam-electric method which uses coal as a fuel. The amount of hydro-electric power which can be

generated is limited by the availability of suitable dam sites. Nuclear power generating plants, although used in Canada, take a long time to build, are extremely expensive, and tend to be unpopular due to the threat of radiation which they pose. The generating capacity of nuclear power plants has not increased as fast as originally thought. Although nuclear power plants will undoubtedly account for a much greater percentage of generating capacity in the future, their effect in the next decade can be assumed to be similar to that of past decades -- minimal. In the near future, therefore, we would not expect hydro or nuclear power plants to have a large impact on the demand for other forms of power generation; at least, not larger than before. However, in the more distant future (20 years or more) the impact of both nuclear and hydro capacity may be very large.[49]

Other methods of power generation require the burning of fossil fuels -- coal, natural gas or oil. Which fuel is burned depends on three things. First, it depends on the initial capital cost of the power plant. Second, it depends on the present and expected future prices of all of the fossil fuels. Future prices are important because the average generating unit has a lifetime which ranges from 15

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49 The James Bay project will probably relieve Quebec of having to rely on coal for electric power generating purposes in the foreseeable future. Ontario is expected to rely more and more on nuclear power generation. But such predictions are highly unreliable.

to 30 years. Building a gas turbine or internal combustion generating unit means that one is committed to burning natural gas or oil for the unit's lifetime.[50] Third, legislative restrictions may prevent the use of one or more of the fossil fuels because of their high sulphur content. If it is technically not feasible or too expensive to reduce the amount of SO_2 (sulphur dioxide) which is released into the atmosphere by the burning of fuels such as oil or coal, then power plants may be built to burn only natural gas rather than coal or oil. This may be the case even though coal or oil may be cheaper, on a b.t.u. basis, than natural gas.

Coal-fired generating units may in some cases be converted to burn only natural gas, but at a cost.[51] Conventional steam-electric generating units can be built so that they can burn either gas or coal, or both in combination.[52] The choice of fuel used at any point in time is governed largely by atmospheric conditions and legislative requirements but also by changes in fuel prices and supply. Although exceptions exist, it can be said that, in general,

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50 See footnote 45.

51 In 1972 four 100-MW units at Ontario Hydro's Richard L. Hearn Generating Station in Toronto were converted from coal-firing units to units which burned only natural gas. However, the first two 66-MW units installed at Wabamun (1956 and 1958) were converted from natural gas to coal burning units in the early 1960's.

52 Four 200-MW units at the Richard L. Hearn Generating Station can burn both coal and natural gas.

once a power plant is built to burn a particular fuel, that fuel is the only fuel which can be burned for the lifetime of the particular generating unit.

For coal-fired plants a further restriction exists. Coal burning plants are designed to burn a particular grade of coal. A higher rank of coal can be burned but not a lower rank. Burning a lower rank of coal reduces the efficiency of the equipment and reduces the unit's lifetime drastically. Hence, if a plant is designed to burn subbituminous coal, high-volatile bituminous coal can be burned but not lignitic coal. Therefore, designers of coal-fired power plants must know which grades of coal the particular coal-fired unit is to burn and operators must be assured a continuous supply of that grade of coal for the lifetime of the unit.

In order to predict the demand for coal by the Canadian electric power generating industry it is necessary to know something about present and planned future generating capacity. Table 7 gives the generating capacity of coal fired power plants by province and electric utility company.[53] Indications of additions to capacity have also been made.

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53 See the map in Appendix B for the location of the various coal-fired power plants.

TABLE 7

Generating Capacity of Coal-Fired Power Plants in Canada by Utility Company and Province (1972)

Province	Capacity (kilowatts)	Number of Plants
Alberta		
Alberta Power Limited	383,500	3
Calgary Power Limited	882,000	2
Alberta Total	1,265,500	5
Saskatchewan		
Saskatchewan Power Corporation	743,000	3
Manitoba		
Manitoba Hydro	392,800	2
Ontario		
Hydro-electric Power Commission of Ontario	6,159,800	6
New Brunswick		
New Brunswick Electric Power Commission	117,500	2
Nova Scotia		
Nova Scotia Power Commission	512,000	4
Canada	9,190,600	22

Source: Chrismas, L. P. "Coal and Coke", *Canadian Minerals Yearbook, 1972*.

> At the end of 1972, existing coal-fired electric power plants had a combined total capacity of 9,190 megawatts (MW). In addition, utility companies in several provinces have announced plans which will result in the construction of thermal plants totalling about 5,240 MW of capacity to be completed within six years. This expansion is expected to occur principally in Ontario and to a less extent in Alberta and Saskatchewan.[54]

Seven 500-MW units will be added to Ontario Hydro's Nanticoke Generating Station near Port Dover on Lake Erie. A 150-MW unit started production at Saskatchewan Power's Boundary Dam Station at Estevan in 1973 and a further unit of 300-MW capacity is scheduled for operation by 1977. This will make the Boundary Dam Station one of the largest lignite-fired power generating stations in North America. In Alberta, Alberta Power is planning to install a 150-MW unit at its Battle River Generating Station at Forestburg and Calgary Power is planning to increase the capacity of its Sundance plant at Wabamun by about 1,140 megawatts over its 1972 capacity.

If we assume that all of the abovementioned plans are made operational by 1977, then Canadian coal-fired generating capacity will be 14,430 MW by this date. Table 8 is a summary of this capacity by province and by type of coal burned.

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54 Chrismas, L. P. "Coal and Coke", Canadian Minerals Yearbook, 1972. Op. cit., p. 11.

TABLE 8

Estimated Generating Capacity of Coal-Fired Power Plants in Canada by Province and Rank of Coal Burned (1977)

Province	Capacity (megawatts)	Rank of Coal Burned
Alberta	2,555	Subbituminous
Saskatchewan	1,193	Lignitic
Manitoba	393	Lignitic
Lignite-fired capacity	1,586	
Ontario	9,660	Bituminous
	117	Bituminous
	512	
Bituminous-coal-fired capacity	10,289	
Canada	14,430	

In order to translate this capacity into a demand for coal several relationships are required.

(1) Capacity refers to the maximum number of kilowatts which a power plant can produce in one hour, i.e. it refers to kilowatts per hour (KWH). Obviously plants do not operate at full capacity all the time and therefore some

type of average yearly load factor is required for calculations. The load factor commonly used ranges from 50 per cent to 70 per cent.[55] In this section we will assume a load factor of 50 per cent or about 4,500 hours of capacity operation per year.

(2) The heat rate refers to the amount of heat required to generate one kilowatt of electricity. Heat is measured in terms of the British thermal unit (b.t.u.). The heat rate is approximately 10,500 b.t.u./KW at present although it can be expected to decrease as more efficient generating units are built and other technological changes are implemented.[56]

(3) The heat content of the various types of coal is found in Table 1. In this section the following heat contents will be used for the different ranks of coal:[57]

Bituminous coal	11,500 b.t.u./lb.
Subbituminous coal	8,500 b.t.u./lb.
Lignitic coal	7,000 b.t.u./lb.

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55 National Petroleum Council. U.S. Energy Outlook: Coal Availability. U.S. Department of the Interior: 1973. p. 58, p. 100.
Korda, B. Competition of Prairie Coals. Research Paper No. 4. University of Alberta, Edmonton: 1972. p. 17.

56 National Petroleum Council. Op. cit., p. 100. The heat rates used in the calculations on p. 100 vary as follows:

1970	11,167 b.t.u./KW,
1975	10,300 b.t.u./KW,
1980	10,100 b.t.u./KW, and
1985	10,000 b.t.u.?KW.

57 National Petroleum Council. Op. cit., p. 58.
Korda, B. Op. cit., p. 23.

Based on the above relationships and data, it is possible to calculate the demand for coal by the electric power generating industry at some future date. The calculations presented in Appendix C estimate the total coal requirements of the electric power generating industry in Canada for 1977 as 33,587,000 tons. Although many sources of error exist in making such a prediction, the estimate does give an idea of the magnitude of the increase in coal-fired generating capacity considering that in 1972 some 17 million tons of coal were used to generate electricity. A discussion of coal use in generating electricity in Alberta and Ontario also sheds some light on the accuracy of the estimates.

In Alberta 4,906,000 tons of subbituminous coal were produced in 1972.[58] Of this about 4.5 million tons was used to generate electricity. As capacity of the coal-fired generating plants almost doubles and the efficiency of coal use increases we should not be surprised at a coal requirement figure of 7.1 million tons for the power generating industry in Alberta. In fact, a priori reasoning may cause us to consider this figure to be on the low side.

Ontario Hydro uses about 9 million tons of coal each year to produce electricity. Almost all of this coal which is imported from the United States under long-term

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58 Statistics Canada. Coal Mines. Catalogue No. 26-206.

contracts.[59] Ontario Hydro has stated that it expects to use over 19 million tons of coal annually by 1980 confirming our estimates.[60] Ontario Hydro feels that only 12 to 13 million tons of this amount will have to be imported with the rest coming from western Canada. Although Ontario Hydro has experimented with western Canadian coals (lignite and subbituminous coal), high transportation costs and supply problems related to a very rapidly expanding coal industry in western Canada may prevent the use of such coals in Ontario for some years.

The provinces of Alberta, Saskatchewan, New Brunswick and Nova Scotia are capable of producing enough coal for their own electric power generating needs. Whereas Ontario relies heavily on coal imported from the rich coalfields of the eastern and midwestern United States, Manitoba imports lignitic coal for its coal-fired generating stations from Saskatchewan.

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59 Recently Ontario Hydro signed a 30-year contract with the U.S. Steel Corporation for 90 million tons of low-sulphur bituminous coal. Delivery is to start in 1976 and to reach 3 million tons annually by 1979.

60 National Coal Association. Coal News. Op. cit., P. 2.

The Demand for Coking Coal

The demand for metallurgical, or coking, coal is a function of the chemical properties of coal rather than its heat content. The demand for this type of coal is a derived demand based ultimately on the final demand for finished steel and is affected by four technological changes. First, coal must be converted to coke. Second, the coke is used in the blast furnaces to melt down the iron ore into hot metal (pig iron). Third, the slag is removed from the hot metal and raw steel is made. Finally, the raw steel passes through a final process in which it is made into finished steel and shipped.

At each stage in the steel-making process there is a weight loss and some conversion factor is used to describe this weight loss. The coal to coke "ratio is not expected to vary from the present level of 1.44 due to the natural chemistry of coal."[61] However, there is a possibility that future technological progress will result in weight loss reductions at the other steps in the process.

> The demand for coke must take into account any foreseeable technical developments in melting practice and the possibilities of exploiting other forms of energy for melting which could affect the demand for coke.... There is no

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61 National Petroleum Council, op. cit., p. 108.

> technical development in blast furnace melting practice for the foreseeable future which is likely to sharply affect the present coke to hot metal ratio. Therefore, projecting the trend of the last 5 years, the coke consumption per ton of hot metal should be 0.58 in 1985 and 0.54 in 2000.[62]

The ratio of blast furnace to raw steel production has remained relatively constant over the last ten years at 0.677. As open hearth furnaces are phased out the ratio is expected to change to 0.64 by 1985 and to 0.60 by the year 2000.[63]

> The yield for raw steel to finished steel (shipments) is increased using continuously cast semi-finished instead of ingot semi-finished. The present 68.5 per cent yield is increased to 80.6 per cent with continuous casting. Overall industry yield could increase to 75 per cent by 1985 and to 80 per cent by 2000.[64]

All of these technological changes will lead to an increase in the demand for coke, and hence metallurgical coal, which is proportionately less than the increase in the demand for finished steel.

With Japanese steel capacity doubling every 5 years in the 1960's and U.S. and European output increasing rapidly as well, those countries producing coking coal benefitted from increasing exports of coal.

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62 Ibid. At present the coke to hot metal ratio is about 0.7.

63 Ibid., pp. 106-108.

64 Ibid., p. 106.

> Beginning in the late 1960's the western Canadian coal producers suddenly found themselves looking at a great world-wide coking coal shortage. (The coal) industry (was) presented with a unique opportunity, not only to participate in this seller's market, but also ... at the same time ... to be established as one of the major long-term world suppliers of coking coal.[65]

Although the United States has enough reserves of coking coal for its own purposes, Europe, South America, Japan, and other countries are not as fortunate since they must import large quantities of coal for their steel industries.

Table 9 presents an estimate of world coking coal requirements for the years 1970 to 2000. Although the U.S. share of the world market is presently about 13 per cent it is assumed that the United States share of the world coking coal market will increase to 20 per cent by 1980 and stabilize at that point. In 1972 Canada produced about 12 million tons of metallurgical coal, or about 3 per cent of the world total. Since Canada's share of the coking coal market is small, the demand curve faced by Canadian producers is very elastic and can be considered to be horizontal. As long as Canadian producers can supply coal at, or below, the world market price, Canadian production can be expanded without practical limit.[66] However, supply aspects will be

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65 Olsen, B. E. "The World-Wide Marketing of Western Canadian Coal", <u>Proceedings of the 24th Canadian Conference on Coal</u>. Edmonton: 1972. p. 3.

66 Whether or not Canada can supply coking coal at, or below, world market price depends on what the market really is as well as on what production costs are. One must talk about a number of market prices since transportation costs have created a number of different geographic markets.

discussed in the following section.

TABLE 9

Estimated World Coking Coal Requirements (1970 - 2000)

(millions of tons)

Year	With Present Practices	With Future Technological Developments	Probable Actual
1970	440	440	440
1975	560	500	560
1980	680	560	650
1985	790	620	750
1990	940	690	850
1995	1,120	760	940
2000	1,230	840	1 ,040

Source: National Petroleum Council. U.S. Energy Outlook: Coal Availability.

Although Australia ships large amounts of coking coal to Japan, the Japanese have also turned to western Canadian producers for some of their requirements. Within the last five years six coal companies with mines or holdings in the Mountain Area have obtained long-term contracts with the Japanese. This has resulted in enquiries from other areas of the world as to the availability of Canadian coking

coal and has also resulted in optimism for the coking coal industry. Some of the more optimistic felt that Canada would be exporting 14 million tons of coal in 1972; 18 million tons in 1973, and 26 million tons by 1975. Although these tonnages have not been realized (and probably will not by those dates), it is obvious that the amount of coking coal which is being exported has risen rapidly. In 1968 about 1 million tons of coal were shipped abroad; in 1972 the figure had increased to over 10 million tons. As Canada becomes a reliable producer of large quantities of coking coal and as long haulage costs (land and sea) are reduced, the output of metallurgical coal can be expected to increase. It is confidently predicted that Canada will supply about one-fourth of Japan's imports of coal for coking purposes in the near future and that shipments of coal to the European market will total some 2 million tons by 1980.[67]

As the map in Appendix B indicates, there are seven coke ovens located in Canada which use metallurgical coal to produce coke for steel-making. In 1972 the total coke capacity of these ovens was 8,281,000 tons of coke per year. If the ovens operated at full capacity 11.9 million tons of coal would be required. However, in 1972, 7.3

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67 Simon, H. P. "The Economic Impact of the Coal Industry in Western Canada", Proceedings of the 23rd Canadian Conference on Coal. p. 23. See also Appendix D.

million tons of metallurgical coal was used and 6.8 million tons of this was imported from the United States.

The three largest steel producers in Canada account for almost 90 per cent of Canadian coke oven capacity.[68] These companies use U.S. coal exclusively and either have captive coal mines in the United States or have long-term contracts with coal mining companies in the U.S., or both.[69]

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68 The three largest companies and their coke oven capacity are as follows:

Company	Coke oven Capacity (tons/year)	Location
Algoma Steel Corporation, Limited	2,100	Sault Ste. Marie, Ontario
Steel Company of Canada Limited (Stelco)	3,400	Hamilton, Ontario
Dominion Foundries and Steel Limited (Dofasco)	1,800	Hamilton, Ontario

Source: Canadian Minerals Yearbook

69 Algoma is developing a low-volatile coal mine at Fairdale, West Virginia which will be capable of producing 1.25 million tons of coal annually. Stelco opened a 700,000 ton per year coal mine at Madison, West Virginia which produces high-volatile coal. Stelco also has a 1/8 interest in a low-volatile bituminous coal mine in West Virginia from which it will receive 870,000 tons annually. Dofasco recently signed a 20-year agreement with Eastern Associated Coal for 500,000 tons of coal per year. This is in addition to an existing 550,000 tons per year contract with this company. Dofasco also has an ownership interest in the Itmann Coal Company of West Virginia from which it receives 250,000 tons of coal annually.

This effectively prevents western Canadian producers from entering this particular section of the market for metallurgical coal. Considering the fact that Canadian coking coal costs about 50 per cent more to transport to the eastern Canadian coke ovens than does U.S. coking coal and the fact that there is no Canadian tariff on imported coal, it is not surprising that imported metallurgical coal is used rather than the Canadian coal.

The fourth largest coke producer, the Cape Breton Development Corporation (Devco), is a crown corporation which has a coke capacity of 900,000 tons annually.[70] Although 77 per cent of the coal used by Devco is from its own mines in Nova Scotia, the remainder is imported from the United States. The major reason for importing coal is the fact that the high-volatile bituminous coal from the Nova Scotia mines is not suited for making coke unless it is mixed with higher ranks of coal (low-volatile bituminous coal). Use of Canadian low-volatile bituminous coal is prevented by high transportation costs.

Although production of coke from the western Canadian coke ovens of the Manitoba and Saskatchewan Coal Company (capacity 110,000 tons of coke annually) and Kaiser

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70 Devco's formation will be discussed later.

Resources Limited (capacity 245,000 tons of coke annually) is insignificant, these coke ovens do use western Canadian coal. But unless a major steel industry is established in western Canada, transportation rates are a barrier which will result in the use of more imported coal as Canadian steel capacity increases. However, Canadian exports of metallurgical coal are expected to increase over the next few decades.

Future Technological Developments and the Demand for Coal

Future technological developments which may affect the demand for coal include the satisfactory resolution of air pollution problems, coal gasification and coal liquefaction. New technology in any of these fields will affect the demand for coal in some inter-related ways. For example, a breakthrough in coal gasification technology without new technology in pollution abatement may not result in a decline of the demand for coal by the power generating industry. Rather it may lead to an increase in demand as power plants burning gas use coal gas rather than natural gas, and gas-fired power plants are substituted for coal-fired plants.

The opposition to coal-fired thermal electric power generating plants is a function of the air pollution which results whenever coal is burned. Unless low-sulphur coal (or other low-sulphur fuel made from coal itself) is available for use in the power plants, some type of stack

gas cleanup system is required. At the moment forms of lime, limestone and dolomite are being considered in the scrubbing of stack gases although more economic systems are expected to follow in the future. The gas scrubbing systems which are now in existence are expensive and often take a long time to install and bring into effective operation.[71] If other, more economic, systems are developed it will take at least 15 years before these systems can be implemented.[72] Hence an increase in demand for coal resulting from an increased desire to build coal-fired power generating plants because these plants will be non-pollutants will not occur for some years.

In the United States optimism over the feasibility of coal gasification is high. As a result, several major natural gas transmission companies have bought up extensive blocks of coal reserves near their pipeline systems, just in case technological developments make coal gas competitive with natural gas as a cheap, clean-burning fossil fuel.[73]

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71 Even at a low cost of \$25 per kilowatt of capacity it will cost \$230 million to fit all of the Canadian coal-fired stations with SO_2 removal systems.

72 National Petroleum Council. <u>U.S. Energy Outlook: Coal Availability</u>. Op. cit., p. 64.

73 Canadian Business Service. <u>Investment Council</u>. Toronto: 1972. pp. 265-6. El Paso Natural Gas Company, Texas Gas Transmission Corporation and American Natural Gas Company are examples of three natural gas transmission companies investing in coal reserves.

> Commercially proved technology to produce synthetic pipeline gas from coal is nearly available and at costs ($0.85 to $1.15 per million b.t.u.'s) comparable to other supplements to domestic natural gas. Improved technology, now under rapid development, may lower costs 10 to 15 per cent, and such improved systems may be available by the end of the projection period (1985).[74]

There are a number of different processes by which coal can be transformed into synthetic gas.[75] However, only for the Lurgi process, which has been used commercially in Europe and South Africa, is any information on costs available. Based on the requirements of a gasification plant delivering 270 million cubic feet of gas daily with the gas having a heating value of about 900 b.t.u.'s per cubic foot, one can draw some conclusions about the feasibility of coal gasification plants in Canada.

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74 National Petroleum Council. U.S. Energy Outlook: Coal Availability. Op. cit., p. 9.

75 Other than the Lurgi process, some of the developmental coal gasification processes are as follows:
(1) A pilot plant using the HYGAS process is being operated to produce coal gas by the Institute of Gas Technology and the Office of Coal Research. It is located in Chicago.
(2)4 Consolidation Coal Company is constructing a pilot plant at Rapid City, South Dakota under the sponsorship of the Office of Coal Research. The plant is being built in an attempt to develop the CSG process.
(3) Bituminous Coal Research, Inc., sponsored by the Office of Coal Research, has designed a pilot plant for the BCR Two-Stage Pressure Coal Gasification Process.
(4) The Bureau of Mines plans a pilot plant for the Synthane process.

(5) The Kellogg Coal Gasification Process has not yet been committed to the pilot plant stage.

The annual tonnage of the three types of coal required for one gasification plant of the above specifications is as follows:

(1)	Bituminous coal (11,500 b.t.u./lb.)	5.7 million tons
(2)	Subbituminous coal (8,500 b.t.u./lb.)	7.8 million tons
(3)	Lignite (7,000 b.t.u./lb.)	9.5 million tons.

If a coal gasification plant is to produce pipeline gas for 15 years then the coalfield (or fields) located near the plant must have recoverable reserves of 86 million tons of bituminous coal, 116 million tons of subbituminous coal or 142 million tons of lignite. As our early discussion, and Tables 2 and 3 show, deposits in Canada are capable of supporting coal gasification plants with the above specifications. For example, the lignite reserves at Hat Creek in central British Columbia are more than sufficient with about 340 million tons of measured reserves.

However, the capital costs of building a coal gasification plant are high. Table 10 gives some indication of the investment required for a complete gasification plant (with the above specifications) starting with stockpiled coal (i.e. excludes coal mine investment) and delivering dried pipeline gas. The investment is given for a plant using western strip-mined coal. Further, an allowance of 15 per cent has been added to the cost of the process plant investment because a detailed engineering analysis was not used in

deriving the estimates nor was a particular plant location chosen.[76]

TABLE 10

Coal Gasification - Lurgi Process - Capital Requirements

(270 millions cubic feet per day of 900 b.t.u. per cubic foot gas)

Process Plants Investment	$132,000,000
Utilities and Offsites	23,000,000
Allowance for Detailed Design	20,000,000
Escalation during Construction	15,000,000
Allowance for Process Development	5,000,000
Miscellaneous (startup, coordination, etc.)	8,000,000
Total	$203,000,000

Source: National Petroleum Council. U.S. Energy Outlook: Coal Availability.

Although coal gasification may be practical in western Canada because of the location of the coal reserves of Canada and the existence of a system of natural gas pipelines, the historic abundance of natural gas, the distance

76 National Petroleum Council. U.S. Energy Outlook: Coal Availability. Op. cit., p. 241.

coal must be shipped if plants are located near the markets and the high capital costs of building coal gasification plants preclude development of Canadian plants in the near future.

The manufacture of hydrocarbon liquids from coal (liquefaction) is still in the research stage. The main obstacle to the development of an economic technique for liquefaction is that of producing a high hydrogen-content liquid from a low hydrogen-content solid. Although many techniques have been developed for making liquids from coal, no know process is considered to be economically viable. Assuming that the needed technology becomes available in the near future, it will still be some 20 years before the manufacture of synthetic liquid fuels from coal is possible on a commercial scale. Once again high initial capital costs (about $123 million spread over 3 years), lack of nearby markets, the historical abundance of fossil fuels other than coal and the efforts in the Athabasca tar sands may prevent the building of coal liquefaction plants in Canada.[77]

It seems likely that the demand for Canadian coal in the near future will not be affected by future possible technological developments. Although more coal will be used to generate electricity, an increase in demand by the electric

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77 The $123 million investment figure is based on the development of a liquefaction plant which has a capacity of 30,000 barrels of syncrude per day and which uses the Amoco process to convert coal into a hydrocarbon liquid.
National Petroleum Council. U.S. Energy Outlook: Coal Availability. Op. cit., p.264.

utility companies based solely on pollution abatement technology is unlikely. Coal gasification or liquefaction on a large scale seems unlikely in Canada for the reasons mentioned earlier. However, rapid increases in natural gas and oil prices could result in some coal gasification and liquefaction taking place in Canada before the year 2000.

<u>Summary</u>

In the next several decades the demand for coal by the electric power generating industry is expected to increase. Assuming that nuclear and hydro-power generating capacity will remain constant relative to total power generating capacity, the exact increase in coal-fired generating capacity will depend upon the interplay of the supply and demand of all the fossil fuels. If this assumption does not hold then the increase in coal-fired generating capacity will also depend upon the rapidity and amount of nuclear and hydro-capacity that is installed. Increases in either type of capacity relative to total capacity will result in a decrease in the rate of increase of coal-fired capacity and hence the rate of increase of coal demand.

At the moment indications are that coal will be relatively important in the power generating industry in the near future. Legislation concerning effluent discharge

standards may reduce the amount of coal-fired capacity being installed, but the industry will probably overcome this restraint by the development of pollution abatement devices. However, the development of such devices is, of itself, unlikely to increase the amount of coal-fired capacity installed.

The demand for coking coal by Canadian steel makers will not be met by the output of Canadian coal producers in the short run because of imports from the United States. The Canadian metallurgical coal output is expected to increase, however, as the world demand for steel increases. Although changes in technology will cause the demand for coal to increase less rapidly than the demand for steel, Canada will be faced with a market favorable to an increasing metallurgical coal output.

Hence, the coal requirements of the steel producers and the electric power generating industry will determine the demand for coal in the next few decades. The use of coal for gasification and liquefaction will be limited in Canada in the foreseeable future.

The conclusions presented above do not agree with those of the Energy Resources Conservation Board of Alberta.[78]

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78 In two recent reports it predicts that Alberta alone will need to produce about 60 million tons of coal by 1985 and 145 million tons by the year 2001. See the following reports:
(a) Energy Resources Conservation Board. Review of the Alberta Coal Industry, 1973. Report 74-E. Calgary: March, 1974.
(b) Energy Resources Conservation Board. The Adequacy of Alberta's Reserves of Surface-Mineable Subbituminous Coal to Meet Market Requirements. Report 74-G. Calgary: April, 1974.

The Board's predictions tend to be very optimistic when compared to those in this section. There may be several reasons for the existence of this discrepancy. First, the board feels that the technological problems of transporting coal to eastern Canadian and U.S. markets can be solved by the use of coal-slurry pipelines. But it fails to mention pipeline capacities and whether or not the existing pipeline system is capable of transporting large quantities of coal if it is also to be used to transport oil from the Athabasca tar sands and the MacKenzie Delta. To build a new pipeline may require large investments in capital -- capital which must come from some other sector in the economy.

Second, and perhaps most important, the Board fails to take into account the environmental impact of mining large quantities of coal (most of which will be mined by surface methods) and the resultant public outcry. The costs of reclamation and the state to which damaged land can be restored are not precisely known although experience in Britain seems to indicate that full restoration can never be achieved and that any respectable degree of restoration can only be achieved at enormous cost.[79]

Third, although coal gasification will become

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79 Whereas in Great Britain reclamation costs were approximately $3,000 per acre restored, in the United States reclamation costs were found to be less than $1,000 per acre.

profitable in the near future, the possibility of having coal gasification plants in Canada within the next few decades is limited by their high capital costs. Development of the oil sands and other investments in energy projects (eg., MacKenzie Valley Pipeline) will limit the availability of capital for coal gasification plants.

Finally, the Energy Resources Conservation Board makes forecasts thirty years into the future. The wisdom of using such a long projection period can be questioned in the light of present-day energy events. Although the Board takes into account any future technological changes which may increase the demand for coal, it de-emphasizes those changes in technology which result in other primary energy forms being substituted for coal. Long range forecasting is difficult and fraught with uncertainty because of an unstable energy situation.

Although the Energy Resources Conservation Board may be proven correct, the above criticisms point out the folly of not considering energy as one sector in the entire economy. Taking a microeconomic view of the energy sector may lead to false conclusions in a dynamic macroeconomic setting. Hence one must take into account all the political, social and economic variables when trying to predict the future need for coal.

CHAPTER IV

THE SUPPLY OF COAL IN CANADA

A. General Comments on the Canadian Coal Industry

Although some of the supply conditions have been discussed, it is useful to look further at the Canadian coal industry to see how the above demand for coal is met. In discussing the various aspects of the Canadian coal industry it may be useful to refer to the literature on the American and British coal industries. The American industry is characterized by low, but increasing, concentration, easy entry, captive markets, discriminating freight rates, and a free, though unstable, market. The British coal industry, on the other hand, is fully nationalized and also is characterized by prices which are not equal to competitive prices. Shortages of coal have been commonplace because of government pricing below the market price, that is, below actual costs (including a fair rate of return).

(1) Concentration

Table 11 indicates that the production of coal had fallen from the 1955 total of 14½ million tons to about 10½ million tons by 1962 in response to a decline in demand, and remained at this relatively low level through the early and mid-1960's. As the demand for coal by the electric power generating industry increased, imports of foreign coal into Ontario (which lacks Quebec's hydro sites) increased as did production of coal for electric generation purposes in the Prairie provinces. Export demand for coking coal by the world's steel producers (especially Japan) was met by increased production of bituminous coal by Alberta and British Columbia and is reflected in the exports column of the Tables. All export of coal at the present time is to Japan on a contract basis.[80] The shift in emphasis of coal production from the Maritimes to the West is also illustrated and will be discussed in more detail later.

In 1955 there were 144 mines operating in Canada. Of these, 42 mines had an annual production of over 100,000 tons each and together accounted for 86½ per cent of total output. Of the 144 mines, 62 mines produced less than 10,000 tons a year.[81] This was hardly a concentrated industry

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80 Test shipments of coking coal have been sent to some South American and European countries.

81 Burchell, D.G. et al. Op. cit., pp. 537-38.

TABLE 11

Summary of Canadian Coal Industry Statistics for Selected Years, 1962-1972

(short tons)

Province	Production	Shipments From Other Provinces	Shipments To Other Provinces	Shipments For Export	Imports From U.S.	Number Of Mines
Newfoundland						
1962	-	87,628	-	-	4,250	-
1967	-	39,782	-	-	12,464	-
1972	-	8,694	-	-	1,285	-
P.E.I.						
1962	-	23,433	-	-	-	-
1967	-	22,432	-	-	-	-
1972	-	18,201	-	-	-	-
Nova Scotia[a]						
1962	4,204,779	842	2,669,250	4,538	102,780	18
1967	3,738,487	-	2,183,419	317	401,145	8
1972	1,425,439	57,827	140,351	71,597	108,989	5

TABLE 11 (continued)

Province	Production	Shipments From Other Provinces	Shipments To Other Provinces	Shipments For Export	Imports From U.S.	Number Of Mines
New Brunswick[a]						
1962	815,529	225,956	86,494	116,039	-	17
1967	837,963	182,229	72,137	-	1,803	14
1972	429,544	28,366	125,351	-	949	1
Quebec						
1962	-	1,981,851	-	-	1,053,989[b]	-
1967	-	459,603	-	-	766,556	-
1972	-	138,518	-	-	669,633	-
Ontario						
1962	-	574,215	-	-	11,153,412	-
1967	-	1,361,983	-	-	14,629,668	-
1972	-	95,946	-	-	17,768,104	-
Manitoba						
1962	-	1,051,664	-	-	6,772	-
1967	-	600,768	-	-	547	-
1972	-	824,663	-	-	8,912	-

TABLE 11 (continued)

Province	Production	Shipments From Other Provinces	Shipments To Other Provinces	Shipments For Export	Imports From U.S.	Number Of Mines
Saskatchewan[c]						
1962	2,256,306	347,669	836,542	246	74	4
1967	2,008,147	504,785	619,059	10,735	-	3
1972	3,282,798	72,116	744,138	7,859	30	3
Alberta						
1962	2,087,310	582	814,176	326,081	-	58
Bituminous	590,139		182,960	325,571		9
Subbituminous	1,497,171		631,216	510		49
1967	3,601,559	116	784,995	783,321	-	35
Bituminous	937,836		113,070	783,222		6
Subbituminous	2,663,723		671,925	91		29
1972	9,024,437	-	276,584	3,607,485	-	24
Bituminous	4,118,747					4
Subbituminous	4,905,690					20

TABLE 11 (continued)

Province	Production	Shipments From Other Provinces	Shipments To Other Provinces	Shipments For Export	Imports From U.S.	Number Of Mines
B.C.[a]						
1962	920,845	283,651	171,049	334,704	150	12
1967	1,209,598	165,413	177,501	417,467	116	5
1972	6,547,098	42,680	-	6,220,314	132	2
Canada						
1962	10,284,769	4,577,491	4,577,491	781,608	12,321,377	109
1967	11,395,754	3,837,448	3,837,111	1,211,840	15,812,299	65
1972	20,709,316	1,287,011	1,287,011	9,907,225	18,558,034	35

a Nova Scotia and New Brunswick produce only bituminous coal as does British Columbia.
b All imports are from the U.S. except some imports from the U.K. for Quebec.
c Saskatchewan produces only lignite.

Source: Statistics Canada. Coal Mines. Catalogue No. 26-206.

considering that total production was only 14½ million tons. However, if we look at the production figures for 1972 we see that the coal industry has become very concentrated.[82] (The transition is depicted in Table 11.) In 1972 the four largest operations accounted for 65.9 per cent of all the Canadian coal output capacity. Of these four operations, three operations were started within the last four years in order to produce coking coal for export to Japan.[83] The fourth operation, Manalta Coal Limited at Wabamun Lake, recently expanded its operations when Calgary Power Limited added to its coal-fired steam generating electric power capacity. As the results of Table 12 show, if intercorporate ownership is considered, 78.4 per cent of total Canadian output is produced by the four largest firms.

The high degree of concentration does not necessarily imply a correspondingly high degree of market power. As will be seen later, the largest coal operators sell to a limited number of buyers, and usually on a long-term contract basis. These buyers include Japan as the

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82 Mines and Resources Branch (Department of Energy, Mines and Resources). Coal Mines in Canada, 1972. Operators List 4: Ottawa.

83 These operations are:
(1) McIntyre Porcupine Mines Limited on the Smoky River,
(2) Kaiser Resources Limited near Sparwood, B.C., and
(3) Fording Coal Limited near Sparwood.

TABLE 12

Estimated Output of the Four Largest Coal Companies in Canada, 1972*

(short tons)

Company	Output
Alberta Coal Limited (Manalta Coal Limited)	6,714,000
Battle River Coal Limited	1,025,000
Alberta operation	550,000
Saskatchewan operation	475,000
Utility Coals Limited (Saskatchewan)	2,135,000
Manalta Coal Limited (Wabamun Lake)	3,554,000
Luscar Limited	1,779,500
Forestburg Collieries Limited	610,000
Manitoba and Saskatchewan Coal Company Ltd.	625,000
Cardinal River Coals Limited**	544,500
McIntyre Porcupine Mines Limited	2,837,000
Kaiser Resources Limited	6,307,000
Total output by the four largest firms	17,637,500
Total Canadian output	22,500,000

* Fording Coal Limited is wholly owned by Canadian Pacific Limited but has only one operation with an output of 1,009,000 tons.

** Cardinal River Coals Limited produces 1,210,000 tons of coal annually but is owned by Luscar Limited (45 per cent) and Consolidation Coal Company of Canada (45 per cent).

Source: Coal Mines in Canada, 1972.
Intercorporate Ownership, 1969.
"Coal and Coke", Canadian Minerals Yearbook, 1972.

present export market, four major utility companies (see Appendix B for the names of the Prairie utility companies with coal-fired capacity) as the main buyers of Prairie coal, and numerous other buyers of the coal output of the lesser firms in the industry. Hence we have an oligopsony situation.

In measuring concentration in a mineral industry it is often difficult to attach significant meaning to measures of concentration based on output or capacity figures alone. One must also consider the ownership of the various coal rights, the quality and amount of coal which they contain, and the accessibility of the coal to market.[84] In other words, the effect of potential entry must be considered in the discussion of concentration. In many cases, however, much information is missing and it becomes difficult to determine which companies will be able to enter

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84 There are three major types of coal rights.
(1) Crown lease: those rights leased from the federal or provincial government. (The federal government holds the ownership rights to minerals in Indian reservations and national parks.)
(2) Freehold: those mineral rights which are held by private individuals or companies. They are not owned by government.
(3) Leased freehold: those mineral rights leased from companies (or individuals) with freehold rights.
See also Energy Resources Conservation Board. Review of the Alberta Coal Industry, 1973. Report 74-E.. Calgary: 1974. pp. 4-1 to 4-3.

the industry as producers. Since a description of which companies hold the various coal rights is inadequate, because of the frequent change in ownership of these rights and the existence of various option agreements, predevelopment exploration activities are described. These provide an indicator of potential entry and hence a barometer for future market concentration.

In the Maritimes little exploration is carried out. The exploration which does occur is meant to provide knowledge which is useful to the future development of existing mines. In Saskatchewan, the provincial and federal governments "have undertaken a $912,000 shared cost program to determine the potential for future development of lignite reserves in southern and central Saskatchewan."[85]

In Alberta and British Columbia the existing producers own a large share of the existing coal rights and carry out much of the exploration activities. Alberta Coal Limited, which is the largest producer of coal in Canada, is exploring the feasibility of producing lignite from the Onakawana field of northern Ontario for power generation purposes. It is also active in exploring its various coal leases in Alberta through its subsidiary, Master Exploration Limited.[86] Canadian Pacific Limited which produces coking

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85 Chrismas, L. P. "Coal and Coke", Canadian Minerals Yearbook, 1973. Op. cit., p. 8.

86 Energy Resources Conservation Board. Report 74-E. Op. cit., p. 4-11.

coal through its subsidiary, Fording Coal Limited, also owns a large number of coal rights and is in the process of exploring these rights through another subsidiary, CanPac Minerals Limited.[87] Other current producers or their parent companies hold extensive coal rights in western Canada.[88]

Other companies which are currently not producing coal but may be in a position to do so at a future date include oil companies (Shell, Imperial Oil, and Scurry-Rainbow Oil), other mining companies with operations in western Canada (Denison Mines Ltd. and Brameda Resources Ltd.), and exploration companies which normally sell or lease their coal rights to those companies in a position to extract the coal.

The power-generating companies also hold many of the coal rights. The City of Edmonton, Alberta Power and Calgary Power hold coal rights in Alberta. The latter two companies have developed some of their coal leases by contracting the extractive operations to coal companies which have leases in the same area as those of the utility company.[89] The B.C. Hydro and Power Authority controls the

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87 Canadian Pacific Limited, formerly the Canadian Pacific Railroad Company, owns coal rights through its subsidiaries CanPac Minerals Ltd. and Canadian Pacific Oil and Gas, Ltd.

88 Both Consolidation Coal Company of Canada (Cardinal River Coals Ltd.) and Canadian Superior Oil (McIntyre Porcupine Mines) hold coal leases.

89 The Calgary Power - Manalta Coal Ltd. operation at Wabamun is a good example.

huge lignite deposits at Hat Creek.[90]

Concentration in the Canadian coal industry will continue to increase as the smaller firms are swallowed up by the larger ones. (Luscar's recent take-over of the Burnstad Coal Company, which had an annual output of 21,000 tons, is an example of the situation.) Entry into the industry is limited to those firms holding rights to extensive potentially recoverable coal reserves. Since most of these rights are held by firms already in the industry, or by firms involved in some other resource extraction industry or by firms which will call upon an experienced coal producer to extract the resource, the number of firms in the industry is unlikely to increase in proportion to increases in output. The industry is likely to become more concentrated.

But concentration is only a characteristic of market structure and thus useful as a guide in determining the origin or cause of poor performance or conduct. But high levels of concentration do not always imply poor performance and hence are not necessarily bad for the economy. In order to understand what is meant here, and in future sections, it may be useful to digress briefly from the main theme of this treatise to consider economic, or industrial, performance.

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90 The Industrial Development Department of the British Columbia Hydro and Power Authority. The Mining Industry of British Columbia and the Yukon. 3rd edition: January, 1968. p. 47.

Performance: A Digression

Good economic, or industrial, performance embodies at least the following four goals and implies, to the extent possible, the maximum satisfaction of these goals.

(a) Scarce resources should not be wasted outright and production decisions should be responsive to consumer demands. In other words, the production process should be efficient.

(b) Entrepreneurs should exploit all technological and market opportunities so as to provide goods at lowest costs and make available new and superior products.

(c) The operations of producers should facilitate full employment of resources, especially human resources. They should not hamper full employment policies.

(d) The distribution of income should be equitable. Producers should not be able to earn excess profits and inflation should not be rampant.[91]

> Performance in particular industries or markets is said to depend upon the conduct of sellers and buyers in those markets in such matters as pricing policies and practices, overt and tacit cooperation among firms, product line strategies, research and development commitments, advertising strategies, legal tactics and

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91 Scherer, F. M. Industrial Market Structure and Economic Performance. Rand McNally and Company, Chicago: 1970. pp. 3-6.

> so on. Conduct depends in turn upon the structure of the relevant market, embracing such features as the number and size distribution of sellers and buyers, the presence or absence of barriers to entry, [product differentiation, cost structures, vertical integration] and so on. Market structure and conduct are also influenced by various basic conditions ... such as the location and ownership of essential raw materials, the character of the available technology, ... the availability of substitute products, ... the marketing characteristics of the product sold and so on.[92]

The perfectly competitive model, which was used by James M. Henderson, is often used for comparison purposes. A perfectly competitive industry is assumed to exhibit good performance. By comparing the basic conditions and market structure of any existing industry with those of the industry if it were assumed to be a perfectly competitive one, an analyst may be able to determine why the existing industry performs poorly.[93] An industrial organization study seeks to find the difference between perfectly competitive and non-competitive industries and between industries with good performance attributes and those without.

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92 Ibid., p. 4.

93 The assumptions and discussion of a perfectly competitive industry can be found in an elementary economics text.

(2) Economies of Scale

In deciding whether or not economies of scale are present we must turn to studies of the United States coal industry because of the lack of adequate Canadian data. Obviously conditions in Canada are not exactly like those of the U.S. but useful comparisons in such areas as mining techniques, labor attitudes and the like can be made none-theless. Much of the mining equipment used in Canadian mines is similar to that used in the U.S.; many of the Canadian workers are members of U.S. unions. Where costs differ this is the result of geological conditions rather than differences in manpower or capital equipment. But geological differences occur between different mines in the United States as well.

The views on whether or not economies of scale exist vary. Maddala's regression analysis reveals that "there are no pronounced indications of economies or diseconomies of scale"[94] in underground mining operations. William Comanor, in his analysis of Moyer's study of the mid-western coal industry in the U.S., was not sure whether economies of scale existed for underground mining operations, although he did say that costs were 20 per cent higher at

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94 Maddala, G. S. "Productivity and Technological Change in the Bituminous Coal Industry", The Journal of Political Economy. August 1965. p. 357.

50 per cent capacity than they were at full capacity.[95] However, this referred to short run average cost curves which were found (by Comanor and Moyer) to slope downwards and then level off as capacity was reached. Only Reed Moyer felt that there were economies of scale in underground mining but that these were insignificant compared to those existing in stripping operations.

> Economies of scale are more evident in strip mining than they are in underground mining.... There is more divisibility in underground mining operations than in strip. Medium-sized deep mines can duplicate the facilities of larger operations, the differences in total output being a function principally of the number of underground "places" worked. Since each face operation works semi-independently of others, the addition of face crews increases total tonnage without measurably increasing productivity.... The opportunities for scale economies in strip mining are limited only by an operator's financial resources and coal reserve position.[96]

The use of caterpillars, trucks and front-end loaders requires a relatively small investment but productivity is much greater when 60 ton scoop shovels, draglines and conveyor belts are used. Obviously Comanor is wrong when he says "that there are unlikely to be substantial scale economies in the case of strip mining".[97]

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95 Comanor, W. S. "Competition and the Performance of the Midwestern Coal Industry", <u>The Journal of Industrial Economics</u>. July, 1966. pp. 212-25.

96 Moyer, Reed. <u>Competition in the Midwestern Coal Industry</u>. Op. cit., pp. 105-6.

97 Comanor, W. S. Op. cit., p. 214.

Perhaps the most important item which determines whether or not economies of scale are present, or can be achieved, is geology. Geology can affect the long run average cost (LRAC) curve in two ways: it can dtermine the height of the LRAC curve and it can, to a lesser extent, determine the slope of the curve. The overburden to coal ratio helps to decide the height of the LRAC curve in strip mining whereas the ratio of coal to other material cut helps to determine the height in underground techniques. Strip mines in which 70 feet of overburden is removed to work an 8 inch seam are going to be more costly to operate on a per unit basis than are strip mines which must remove 70 feet of overburden to mine a 12 foot seam. Mining a 36 inch seam is often more costly than mining a 7 foot seam when one considers underground operations.

The slope of the LRAC curve is also affected by a number of complex, often unknown, geological factors. However, in discussing the slope of the curve one turns to the factors mentioned earlier. Size of plant (size of equipment used, type of mining, and the like), managerial ablility and other factors help to determine the slope of the LRAC curve. Although the factors dtermining the slope of the curve are related to those determing the height of the curve, the two concepts should not be confused.

In a large market such as that which exists in the United States, we can say that "scale economies are as attainable under an atomistic market structure as they are under oligopoly."[98] As such they do not constitute a serious barrier to entry in the U.S. because minimum efficient scale is small relative to market size. But is the same true for the Canadian coal industry?

Although a large market for thermal and coking coal exists in Ontario and Quebec, the large distances involved in transporting Canadian coal from the mines to these markets preclude the sale of this coal at prices equal to or below the laid-down cost of imported U.S. coal.[99] Hence, the Canadian thermal coal operations which exist serve the

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98 Moyer, Reed. Op. cit., p. 108

99 At the moment there is no tariff on imported coal. In 1967 there was a tariff of $0.50 per ton of bituminous coal imported for non-metallurgical purposes. In 1968 it was reduced to $0.10 per ton and eliminated as a result of GATT's Kennedy Round in 1969.

Coal from western Canada can be sold in eastern Canadian and U.S. markets in mid-1974 because of the high prices for coal in the U.S. The reason for this is the inability of U.S. production capacity to meet demand requirements. This situation will change however as the U.S. government plans to pump over a billion dollars into the U.S. coal industry over the next two years to increase capacity. Further, Canadian producers are aided by federal help.

smaller regional markets. Although these markets (the markets for thermal coal in the three Prairie provinces) can accommodate only a few firms at minimum efficient scale (MES), operators can exist at production levels much below MES because transportation costs are large relative to extraction costs (even over short distances).

The market for coking coal, which is mainly an export market for Canadian producers, is large relative to minimum efficient scale but this does not prevent minimum efficient scale from being a barrier to entry. For example, the minimum efficient size plant is small relative to the world market for automobiles but it still constitutes a large barrier to entry. Economies of scale may matter little where the markets for coal tend to be local farmers or coal-fired generating plants (subbituminous and lignite coals), but in considering coking coal and exports to Japan (Mountain Area producers) one realizes that there is more to producing than just taking the coal out of the ground. Preparation plants, port facilities and other costly items must be considered as well. But to relate a minimum efficient size to market size is difficult. Neither the market (various parts of the world depending on ability to compete by overcoming geographical barriers) nor MES is well-defined. The Canmore Mines Limited seems to thrive amongst the giants of the Mountain region with its annual

output of 200,000 tons which is divided between underground (150,000 tons) and surface (50,000 tons) operations. However, Canmore Mines Limited "is somewhat handicapped by its low annual production level, and an inability to market the coal elsewhere than in Japan.... (It hopes) to increase its current production to a more viable level of 550,000 tons per year by 1977."[100] Hence, it seems that minimum efficient scale in the Canadian coking coal industry requires an output of 500,000 tons per year or more.[101]

(3) Productivity, Capital Costs and Profitability

The productivity of underground mines is significantly different from that of surface mines as figure 9 shows. But what has caused the increase in the average productivity of all Canadian coal mines over time? According to Maddala:

> the main conclusions (on technological change) that follow ... are that, if capital is measured by the horsepower-rating of power equipment, there is no significant change in the structure of the aggregate production function over such a long period as 1919 - 1954 and that the increase in labor productivity over this period can be almost totally

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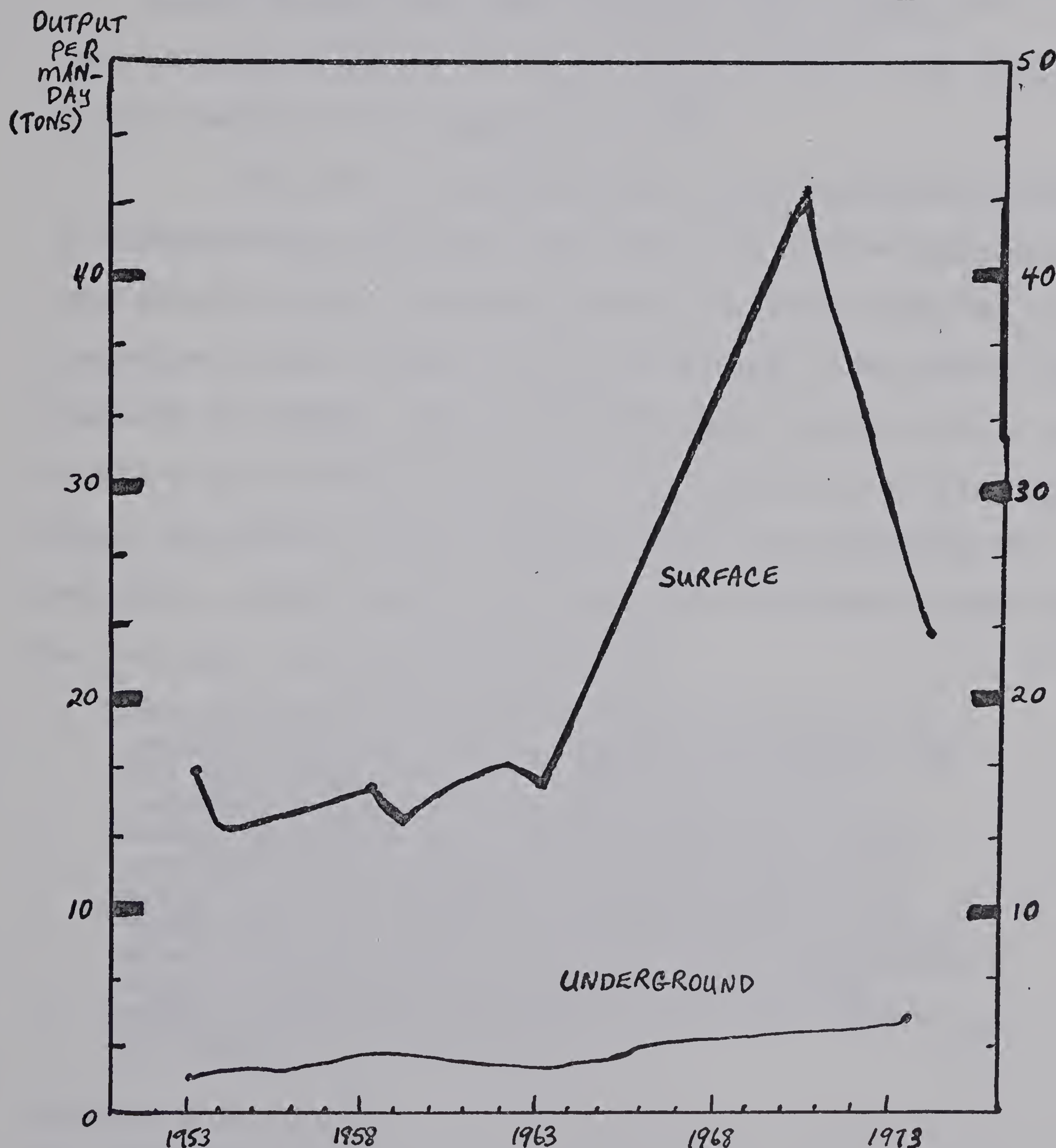
100 Energy Resources Conservation Board. Report 74-E. Op. cit., p. 1-10.

101 Canmore Mines Limited is able to survive at such a low production level because its product is slightly differentiated from the other producers since it produces some anthracite. However, Canmore Mines Ltd. still needs to expand production to attain a "more viable" level of production, i.e., to attain MES.

FIGURE 9

Average Output per Man per Day in Canadian Underground and Surface Mines -- 1953-1972



Source: Statistics Canada. Coal Mines. Catalogue No. 26-206.

> explained by the increase in horsepower-rating of equipment per worker, the substitution between the two factors having taken place in response to change in relative factor prices.... The increased labor productivity is almost entirely attributable to the increase in the horsepower equipment per worker.[102]

The remaining increase in labor productivity is due to a change in the quality of the labor force.[103]

The cost of producing coal from underground mines is significantly different from the cost of producing coal from surface mines. Although there is little detailed information on the average capital investment per unit of coal produced in Canada, such information does exist for the coal industry in the United States. By comparing the U.S. capital costs with those of the Canadian Mines for which data is available, useful ideas about Canadian investment costs can be obtained. In the United States,

> the investment required to open a new mine is greater than the average capital investment for all mines currently producing coal. For example, information for the year 1970 indicates that original capital investment for a new mine ranged between \$8.00 and \$20.00 per annual ton of production. However Table 13 shows that the average original capital investment per annual ton of production at underground mines in 1970 was estimated by the economic model (computer model used by the U.S. Bureau of Mines) to be only \$7.15.[104]

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102 Maddala, G. S. Op. cit., p. 364.

103 Ibid.

104 National Petroleum Council. <u>U. S. Energy Outlook: Coal Availability</u>. Op. cit., p. 38.

In Canada capital investment requirements per annual unit of output are very similar to those in the United States since they tend to fall in the $8.00 to $20.00 range per annual ton of production. For example, McIntyre Porcupine Mines Limited and Cardinal River Coal Limited spent $46 million and $14 million respectively, in initial construction and investment costs.[105] From Table 12 we see that these companies have outputs of 2.8 and 1.2 million tons annually. Hence, Canadian investment costs seem to be similar to those of the United States. The predictions (estimates) of Table 13 can, therefore, be used as an indicator of required Canadian capital investment in coal mining in order to meet the predicted levels of Canadian output.

Profitability in the Canadian coal industry tends to be rather low vis-a-vis the profitability in other industries. Figure 10 compares the average rates of return on total capital during the 1960's for various industrial groupings including the grouping known as "mineral fuels". It is apparent from this diagram that the mineral fuels grouping had the lowest rate of return during the 1960's.

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105 Energy Resources Conservation Board. Report 74-E. Op. cit., pp. 8-3 to 8-4.
Also see Crump, N. R. et al. Final Report: Grande Cache Commission. Alberta Grande Cache Commission, Edmonton: 1974. pp. 155-157.

TABLE 13

Estimated Average Capital Investment per Annual Ton Of Production at U.S. Coal Mines -- 1970-1985

(30 Year Life -- Constant 1970 U.S. Dollars)

(millions)

	Operating Year							
	Underground Mines				Surface Mines			
	1970	1975	1980	1985	1970	1975	1980	1985
Original Capital Investment	7.15	8.46	9.20	9.84	6.39	7.33	8.07	8.78
Total Capital Investment Over Life of Mine	19.66	23.17	25.03	26.64	10.59	12.15	13.79	14.44

Source: National Petroleum Council. U. S. Energy Outlook: Coal Availability.

However, Malhotra, using regression analysis techniques, forecasts a rising rate of return on total capital employed in the mineral fuels sector during the 1970's.[106] In spite of the fact that the profitability for this sector has increased in the early 1970's and is expected to continue to

106 Malhotra, S. P. Return on Capital Analysis and Forecast in the Canadian Mineral Industry. Mineral Bulletin MR 118. Mineral Resources Branch, Department of Energy, Mines and Resources, Ottawa: 1971. pp. 36-43.

FIGURE 10

Average Percentage Return on Total Capital Employed

By Major Mineral Industry Sectors

Percentage Zones

13% ——————————————————————— 13%

* Metal Mining

11% ——————————————————————— 11%

* Other Mining

9% ———————— * All Mining ———————— 9%

* Nonmetallic Mineral Products

* All Industries
* Primary Metal Industries

* Mineral Based Manufacturing

7% ——————————————————————— 7%

* Petroleum Products

5% ——————————————————————— 5%

* Mineral Fuel Mining

Source: Malhorta, S. P, Return on Capital Analysis and Forecast in the Canadian Mineral Industry.

do so as a consequence of the energy crisis, the same cannot be said of a minor component in the Canadian mineral fuels sector -- the coal industry. Table 14 compares the profitability of the coal industry with the total mineral fuels group for the years 1965 through 1970.[107] It is obvious that the coal industry is not as profitable as the other industries in the mineral fuels group.

Although the last two years in Table 16 show negative profits in the coal industry, these are the result of large producers (mainly Mountain area coking coal producers) encountering various problems in entering the coal industry and the continued government rationalization of the Nova Scotia and New Brunswick coal industries (to be discussed later). Negative, or near zero, profits were registered during 1970 through 1973 as well, as various coking coal operators continued to be plagued with entry-at-large-scale difficulties and contractual problems arising from unstable international monetary markets.[108]

Whether or not profits in the Canadian coal industry will rise with those of the mineral fuels sector will depend upon future production costs, market conditions

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107 More recent Statistics Canada data were unavailable.

108 Fording Coal Limited entered the industry in 1972. McIntyre continued having mining problems as well as contract difficulties.

TABLE 14

Comparison of the Profitability of Coal Mines and The Total Mineral Fuels Extraction Group -- 1965-1970

Year	Total Assets ($000,000)	Net Profit Before Income Taxes ($000,000)	Rate of Return on Total Assets (Per Cent)
		Coal Mines	
1965	84.4	0.0	-
1966	69.1	2.6	3.8
1967	104.3	3.3	3.2
1968	130.6	4.5	3.4
1969	190.2	-0.6	-
1970	236.5	-0.7	-
		Mineral Fuels Extraction	
1965	3,676.9	194.8	5.3
1966	4,127.5	182.8	4.4
1967	5,611.4	338.3	6.0
1968	6,056.1	342.5	5.7
1969	5,168.3	314.6	6.1
1970	5,729.9	277.2	4.8

Source: Statistics Canada. Corporation Financial Statistics. Catalogue No. 61-207.

and other factors.[109] The Grande Cache Commission, which investigated the viability of the McIntyre Porcupine Mines Limited operation on the Smoky River in Alberta, felt rather optimistic about McIntyre's chances of changing its negative profit operation to a more viable one in the short term but questioned the medium and long term (7 or more years) possibilities. However, one of the three Commissioners, Professor T. H. Patching, questioned the company's viability given "the experience of several other coal producers (with) price changes that have lagged by some period of time behind increases in costs."[110] If rates of return do not improve in the future, one would expect a shift of capital from the coal industry (i.e. exit of some firms) to other sectors of the economy unless non-competitive elements, such as the interference of government in the market, exist.

(4) Barriers to Entry

What are the barriers to entry into the Canadian coal industry? Although there are numerous barriers to entry, only those which might be (or could become)

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109 The income of a corporation derived from the operation of a mine was exempt from income tax for a three-year period starting with reasonable commercial quantities of output from the mine. This was discontinued in the 1971 Income Tax Act although it held until the end of 1973 for existing producers.

110 Crump, N.R. et al. Final Report: Grande Cache Commission. Op. cit., p. 131.

prohibitive are discussed.

Large financial outlays to achieve an efficient (competitive) size plant may deter entry. However,

> Baratz reports that "the intended output and degree of permanence of a coal mine determines its initial investment cost, beginning at perhaps $1,000 for a punch mine, and from $10,000 for a strip mine to $1,000,000 for a permanent large-scale strip-mining tract. For a deep mine producing high-quality washed coal, initial capital requirements run between $1,000,000 and $2,500,000." Although $2,500,000 is not a trivial sum, it hardly constitutes a serious barrier to entry. [111]

But, given the results presented above, such investments result in mines which have a small annual output.

The existence of economies of scale does not seem to constitute a serious barrier to entry in the Canadian coal mining areas, such as Nova Scotia and the Plains Area of Alberta, where small local markets exist and these markets are isolated geographically by the high costs of transporting coal relative to the extraction costs. These local markets include farmers and agencies, such as pulp and paper mills, which require coal for heating purposes. However, economies of scale do tend to be a barrier to entry for those firms wishing to enter the coking coal industry, as was mentioned earlier.

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111 Williamson, O.E. "Wage Rates as a Barrier to Entry: the Pennington Case in Perspective", The Quarterly Journal of Economics. February, 1968. p. 112.

Patents and know-how can also constitute a barrier to entry. One reason cited for McIntyre Porcupine's losses was the fact that the Company had no experience in coal mining nor did it have competent "coal people". Firms already in the industry tend to have superior information and knowledge. Existing firms may also have an advantage where imperfect markets exist. Existing firms may be able to borrow capital at lower rates of interest than can potential entrants. Existing firms may have less trouble purchasing expensive mining equipment, with certain specifications, from the manufacturers.

> Existing firms require lower profits to remain in the industry than outsiders need to induce their entry because the former, merely by surviving, have proven that they can overcome the risks inherent in the industry. The outsiders remain untested.[112]

As shown earlier, profits tend to be low in the coal industry compared to the other mineral industries.

Another barrier to entry is ownership of reserves. Those companies which own large reserves of good "quality" coal can exclude other firms from entering. Where marginal firms (those holding smaller or poorer quality reserves) do enter, the firms operating in the better reserves can earn an economic rent. This "excess profit" can be used

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112 Moyer, Reed. Competition in the Midwestern Coal Industry. Op. cit., pp. 133-134.

to expand their market power through internal growth or through mergers. Ownership of coal reserves is then the most effective barrier to entry.

Long-term contracts also constitute a considerable barrier to entry because long-term contracts exclude potential entrants (and existing firms) from a portion of the market -- that which is accounted for in the contract. The same effect occurs in the case of vertical integration. However, captive markets lead to stable prices and make profits more secure.

> Typically a long-term contract specifies a mine price which fluctuates in response only to changes in production costs. The escalation provisions spell out detailed methods for adjusting prices in response to wage-rate increases, changes in supply costs, and general and administrative cost adjustments. Thus if an operator carefully controls his costs, the contract guarantees relatively constant profit margins for the life of the agreement. Many contracts even provide protection to profit margins from the erosion of inflation, granting price adjustments in response to changes in the general price level.[113]

In Canada, all the coking coal is shipped to Japan on a long-term (15 year) contract basis. Although some coking coal is shipped to other countries, the amount is small and is used to explore potential markets. Given that some companies have had problems even in meeting the Japanese contracts, it seems that there is no excess capacity that

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113 Ibid.

might be used to serve other markets. However, most of the managers in the Canadian coking coal industry feel that capacity will increase in the future as the relatively new firms become established in the industry. Unless a potential entrant has a contract for selling coking coal (Japan has awarded few contracts in recent years and no Canadian producer, or potential producer, has a contract to sell coking coal elsewhere), he cannot enter the industry. Most of the producers on the Prairies have long-term contracts with the power companies. This effectively prevents entry (unless a new power plant is built) because most of the coal used on the Prairies is for thermal power generation. The electric utilities and steel mills need long-term contracts to ensure that they will have enough coal to meet plant requirements. Before building a power plant to be fueled by coal, one must be sure that the coal is available for the life of the plant.

Traditionally entry into the coal mining industry has been relatively easy but exit has been more difficult. Entry occurred whenever demand increased; exit occurred whenever demand fell. But because exit occurred at a much slower rate vis-a-vis entry and related fluctuations in demand, excess capacity was, and perhaps still is, a problem to plague the coal industry. Some mines (such as those in the Drumheller area) operate only on a seasonal basis and are closed for parts of the year. Some mines are opened

during periods of high demand but are forced to close when demand falls. However, the mine and its workings are still there and it is often cheaper to keep the mine in workable condition (in the hopes that demand will rise in the future) than it is to allow the mine to deteriorate completely. This is especially true of underground mines. This type of situation leads to excess capacity and excess capacity, in turn, raises the barriers to entry, or, perhaps one should say, lowers the incentive to entry. Considering the increasing demand for energy and the problems in meeting this demand, such a phenomenon is confined to local markets, such as that of the Drumheller area.

B. Regional Breakdown of the Canadian Coal Industry

Although we have been discussing the Canadian coal industry as if it were a single industry, we should separate the industry into the three separate entities (or industries) frequently referred to above; namely, the Maritime region, the Prairie region and the Mountain region. The bases for this distinction are both geography and differences in the type of product. Due to vast distances, the coal of the Maritime region does not compete directly with western coal. Although Ontario might be a plausible area where they could compete, transportation costs and other factors which are discussed in this section prevent this from taking place.

Mountain coal should be separated from Prairie coal because they are two different types of coal. Mountain coal is of a metallurgical variety and is used only in the iron and steel industry. As such it is exported.[114] Prairie coal is used locally for power generation purposes although markets in eastern Canada and the United States are being sought.

(1) Maritime Region

The Maritime region was at one time the dominant coal mining area in Canada. However, beginning as early as 1927, Federal subventions (transportation subsidies) were required to bring the coal to the Ontario and Quebec markets. The cost of these direct subsidies was about $29.5 million in 1966 and $32.0 million in 1967 although the cost fell to $8.9 million in 1968.[115] As Table 15 shows, these payments constituted a very large proportion of the total Federal

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114 Slack, or waste coal, from the coking coal operations is used for power generation in some cases (H. R. Milner Power Plant) but this does not constitute a real threat to Prairie coal because of the costs of extracting coal for this purpose alone.

115 The subvention payments were divided between the provinces of Nova Scotia and New Brunswick as follows:

	Nova Scotia	New Brunswick
1966	$27,610,279	$1,925,500
1967	29,583,325	2,421,328
1968	5,224,405	3,705,644*

*Subvention total includes $1,126,257 paid to the Province of New Brunswick in 1968.

subvention payments. Other direct and indirect subsidies were also made by the provincial and federal governments to the Maritime coal industry. The Atlantic Provinces Power Development Act of 1958 provided some $1.5 million annually. These payments indirectly aid the marketing of Maritime coal. In 1962 and 1963 special subsidies were provided to Maritime producers who shipped coal to markets where the coal was in direct competition with imported residual oil. These subsidies amounted to ten cents per ton for New Brunswick producers and 30 cents per ton for Nova Scotian producers; or about $740,000 annually. Further subsidies included a Federal grant of $4 million in 1969 to aid the coal industry in the Minto area of New Brunswick and other subsidies arising out of nationalization schemes.

In 1966, the subvention payments for coal from the Glace Bay-Sydney region of Cape Breton Island were equivalent to a $3,700 subsidy for every miner working in this region's coal mines. The industrial base of this area was a steel and coal industry operated by the Dominion Steel and Coal Company. In 1965, the Company indicated that it no longer wanted to operate unprofitable coal mines. Rather than let the industrial base of the area collapse (6,200 men were employed by the coal industry and 3,500 by the steel industry), socio-economic and political pressures resulted in the provincial and federal governments creating a Crown corporation -- the Cape Breton Development Corporation or Devco. Devco had

TABLE 15

Coal Moved Under Subvention Payments -- 1959-1968

Year	Origin of Coal: Nova Scotia	New Brunswick	Saskatchewan	Alberta and British Columbia	Total Canada	Total Value of Subvention
1959	2,154,034	137,613	111,006	323,813	2,716,466	$13,420,799
1960	2,048,073	173,063	79,377	685,797	2,986,310	16,344,196
1961	2,323,684	146,201	104,807	758,011	3,332,703	17,854,456
1962	2,191,938	114,186	82,511	692,394	3,081,029	17,433,355
1963	2,428,819	191,766	89,311	780,085	3,489,981	17,543,915
1964	2,336,571	407,120	128,215	1,052,526	3,924,432	17,194,381
1965	3,465,093	582,192	176,224	1,125,317	5,348,826	26,669,551
1966	3,647,386	767,899	200,273	1,167,295	5,782,853	32,968,260
1967	3,415,230	687,125	269,695	1,256,068	5,628,118	35,722,532
1968	729,648	767,832	185,852	1,351,337	3,034,669	12,791,699*

* Subvention total includes $1,126,257 paid to the Province of New Brunswick in 1968.

Source: "Coal and Coke", Canadian Minerals Yearbook.

two purposes. First, it was to rationalize the industry by gradually phasing out the more uneconomic coal mines. Second, Devco was to introduce a new economic base into the region. The rate at which mines were phased out depended upon the rate of development of a new economic base. As a result, production of coal from this particular area dropped from 3.3 million tons in 1966 to about 1.7 million tons in 1972. Since Devco accounted for 70 per cent of total Maritime production and 87 per cent of total Nova Scotia production in 1971, this represented a large drop in Maritime output.

The second largest producer in the Maritime region is also a Crown corporation, New Brunswick Coal Limited, owned by the Province of New Brunswick. This Crown corporation was set up in order to rationalize the industry by changing production from underground mining to surface mining. All production from this company is now from stripping operations, the last underground mine having been closed in 1971. New Brunswick Coal Limited accounted for 20 per cent of Maritime production in that year. Four smaller underground operations in Nova Scotia account for the remaining 10 per cent of output.

Although the Maritime region is characterized by high concentration due to nationalization, the industry has declined rapidly since 1967. Eventually the coal produced in the Maritimes will be sold locally to the steel mills, power plants, space heating agents (mainly farmers) and the

pulp and paper mills. Coal from this area was slowly pulled off the Ontario and Quebec markets where it is not competitive without the large subventions. This is shown in the "shipments from other provinces" column in Table 11. Although the subventions have ceased the government still subsidizes the industry in various ways.[116]

In looking at the performance of the coal industry in the Maritime region one must remember that the industry of the region was in a state of decline due to a general decline of demand for the region's coal output. It is obvious that government intervention prevented the withdrawal of excess capacity -- a withdrawal which would have occurred had the industry been a perfectly competitive one in which government intervention did not occur. Although performance of the industry was probably hurt by the government intervention (and probably still is), this intervention should not be condemned because other elements enter into the complicated workings of this particular industry.

(2) Prairie Region

The Prairie region has been characterized by free entry and exit. Whenever the demand for coal increased, the

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116 In 1969, for example, the Federal government, which underwrites all of Devco's losses, was required to pay $21 million to cover the losses of Devco's coal division.

number of mines increased as well. In the five years prior to 1956, when demand was declining, 182 mines were closed.[117] Most of these mines were small and produced bituminous, subbituminous and lignitic coal for the local markets. When the demand for coal rose again in the late 1960's the structure of the coal industry was different than it was in 1950. It had changed from one characterized by numerous small firms operating underground mines to that of large firms operating strip mines in order to supply the growing electric power generation market with coal which is competitive with other fuels on a b.t.u. basis.

In 1972 one firm and its subsidiaries (Manalta Coal Limited) accounted for 6.7 million of the 8.0 million tons (83.75 per cent) of coal mined in the Prairie region. Two firms, Manalta Coal Limited and Forestburg Collieries Limited (with its subsidiary the Manitoba and Saskatchewan Coal Company Limited) accounted for 98 per cent of total output in the Prairie region. Eleven other firms (two of which operated underground mines) accounted for the remaining 2 per cent of output. Almost all of the coal produced by the two largest firms was sold to electric utility companies under a long-term contract basis.

To say that the two largest firms were dominant in

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117 Burchell, D. G. et. al. "Underground Coal Mining in Canada". Op. cit., pp. 537-38.

the sense that they had a large degree of market power is not quite right. Competition was provided not only by other fuels but also by the threat which existing or potential producers with coal rights always pose. Further, many of the coal reserves were not owned by the coal companies but rather by a particular electric utility company. Even though there was a high degree of concentration in the seller market, a large degree of concentration also existed in the buyer market. Other than a few farmers and other local domestic users, the large electric utility companies constitute the only real demand for coal.

As Table 15 indicates, some subvention assistance was provided to the Prairie region coal industry. However, the amount of assistance was small (about $150,000 annually) and the majority of it was used to move coal to the non-coal producing areas of the Prairie provinces, mainly to subsidize the movement of Saskatchewan coal to Manitoba. Without subvention assistance, or some other type of subsidy, it is unlikely that Prairie coals will be used to generate electricity in Ontario or Quebec.[118]

In conclusion, one can infer that the performance (or at least the behavior) of the coal industry of the

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118 All subvention assistance was to end March 31, 1970 although two coking coal producers were granted 1 year extensions. However, a recent article in the Financial Post (June 8, 1974) indicated that ½ million tons of thermal coal will be sent to Ontario with some government assistance because "it is to the country's advantage ... to lessen the dangerous dependency on the U.S."

Prairie region tends to approach that of a competitive industry. However, the increasing concentration of the industry's output in the hands of a few firms and the possibility of government intervention may change the behavior of the industry substantially.

(3) Mountain Region

The Mountain region accounts for over one-half of total coal output in Canada. Although output was about 1½ million short tons in 1968, it had risen to about 12½ million tons by 1972. Several features set the Mountain region apart from the other coal mining regions. First is the degree of foreign ownership. Of the six companies operating in the Mountain region only one is Canadian owned and controlled. Fording Coal Limited is wholly-owned by Canadian Pacific Limited through its subsidiaries Canadian Pacific Investments and Cominco Limited.[119] The indications are that the amount of financial backing required to carry out mining operations in this region is large.

Second is the fact that there is only one buyer of the coking coal produced in the Mountain region. The

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119 Canmore Mines Ltd. is wholly-owned by Dillingham Corporation of the U.S. Cardinal River Coals Ltd. is owned by the Continental Oil Company (45%). McIntyre Porcupine Mines Ltd. is controlled by the Superior Oil Company (37.4%). Kaiser Resources Ltd. is a wholly-owned subsidiary of Kaiser Steel Corporation.

Japanese steel manufacturers, acting as a cartel, all have contracts with the six Canadian producers of coking coal. The terms of these contracts are given in Table 16. Although these contracts have been made, there are reasons to believe that output could be expanded thus making it possible for producers to vie for other markets.[120] However, the fantastic growth in capacity within four years has not been without costs. Labor problems have beset several of the companies (McIntyre Porcupine Mines and Fording Coal have experienced labor difficulties sufficient to prevent the meeting of contractual obligations), many transportation problems still have to be overcome (McIntyre Porcupine Mines is still puzzling over the question of transporting coal from its No. 9 mine to its preparation plant), and geological problems face each producer.

Third, the industry has been subsidized by both the provincial and federal governments even though the coal produced was meant to be exported. Prior to March 31, 1971 subvention payments were a characteristic as Table 15 shows. In 1962 these subvention payments reached $2.4 million; in 1963, 762,578 tons of coal were exported from the Crowsnest Pass area with the aid of $2.5 million subvention. Although

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120 The main reason for believing this is the amount of coal exported to other markets in the form of test shipments.

TABLE 16

Export Contracts of Coking Coal to Japan

Company	Annual Shipments (millions of long tons)	Price f.o.b. Vancouver as of May 15,1973 (U.S. $)	Term
McIntyre Porcupine Mines Limited	1.25	21.95	1973-74
Cardinal River Coals Limited	1.0	14.30	1970-84
The Canmore Mines, Limited	0.15	14.88	1968-77
Coleman Collieries Limited	1.0	18.73	1967-82
Fording Coal Limited	3.0	17.73	1972-86
Kaiser Resources Limited	4.5	18.73*	1973-85

* Will increase to $19.85 (Canadian) on July 1, 1973.

Source: "Coal and Coke", Canadian Minerals Yearbook.

Final Report: Grande Cache Commission.

subvention to coking coal producers ended in 1971, other forms of subsidy have come in their place. For example, the Alberta government subsidized the operations of McIntyre Porcupine Mines Limited on the Smoky River near Grande Cache. Not only did the government build a railroad, road and town in support of the coal mining operations but it also provided an indirect transportation subsidy.

In the early 1960's, when McIntyre Porcupine first thought about producing coal from the Smoky River site, Canadian National Railways said it would build a branch line to the Smoky River operations if it were guaranteed a shipment of 1 million tons of coal annually at a rate of $5.50 per ton to the coast (Vancouver). McIntyre did not go ahead with coal contract negotiations until the decision to build the Alberta Resources Railroad (A.R.R.) had been made.[121] In 1965 the C.N.R. quoted a price of $4.45 per ton for shipment of coal to the coast on the basis that the A.R.R. would receive $1.40 of this amount in order to regain some of its capital cost. However, McIntyre Porcupine Mines Limited felt that it could not be competitive unless the rate was $3.13 per ton. This freight rate was based on a contract which gave the coal company a 12 per cent rate of return (a "reasonable rate of return" according to the parties involved).

121 The Province of Alberta decided to build the railroad to encourage the contract negotiations so that coal would eventually be extracted from the region. Initially it was thought that only coal would move along the railroad, at least for the first ten to fifteen years.

Since the A.R.R. was already partially completed by this time, the provincial government had no choice but to retreat to a lower freight rate. Coal was all that would be moved along the railroad! The government reduced its rate from $1.40 per ton to $0.50 per ton and McIntyre negotiated a contract based on cost (including the artificially lower freight cost) plus a reasonable rate of return.[122] But

> on the 15 year, 29.5 million ton contract, this reduction amounted to over $26.5 million. This reduction, assuming the original $1.40 rate was a proper one, can only be characterized as a subsidy -- to the purchasers of the coal if they were truly buying on a "cost plus" basis; to the Company otherwise.[123]

A further revelation of the Smoky River operation may be useful. McIntyre Porcupine Mines Limited negotiated its first contract (15 years -- 29.5 million tons) on the basis that all of the output would be produced by underground methods. It should be noted that none of the consultants' studies to July 9, 1968 (the date of the study on which final negotiations were based) "placed any reliance on the availability of coal from surface or open pit mining."[124] However, when underground mining proved not feasible both because of cost and because of failure to meet contractual

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122 Crump, N. R. et. al. <u>Final Report: Grande Cache Commission</u>. Op. cit., pp. 10-16.

123 Ibid., p. 15.

124 Ibid., p. 17.

commitments, McIntyre was able to open a small surface mine in early 1971.

> Mining by open pit methods has been continued since then by a contractor. Output has increased until it is greater than underground production, and operating costs are less. Additional tonnages have been found which can be mined by open pit methods, and the method has become very attractive to the Company.[125]

Even with these changes, McIntyre could not overcome some of the other problems in meeting the annual 2 million long ton commitment of the contract. By mutual agreement, a new contract was made late in 1972 and the old one cancelled.

The degree to which other companies in the Mountain region are subsidized is unknown. The above information became available only after a public inquiry into the Smoky River operation was called for. But it is known that all the companies in the Mountain region use surface techniques to recover the coal and that these surface methods account for about three-quarters of the Mountain region's output.[126] This in spite of the fact that less than ten per cent of the region's coal reserves are recoverable by such methods. Although four operations carry out underground mining, the recent trend has been towards increasing the proportion of output from the stripping tracts relative to that of underground output.

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125 Ibid., p. 34.

126 Fording Coal Ltd. and Cardinal River Coals Ltd. use surface methods exclusively.

High foreign ownership, the fact that the coking coal is being sent to Japan, and the high incidence of surface mining raise some interesting questions of a cost-benefit nature. How much do Canadians benefit from these types of operations? To take into account all of the factors and come to a conclusion is not within the scope of this treatise. Therefore, let us raise some questions. How extensive and permanent is strip mining damage? How does one evaluate the scenic amenities associated with intact wilderness areas? By how much does Canadian employment really rise, remembering that strip mining requires less labor per unit of output than underground mining? In this context we must distinguish between a fully employed Canadian economy and an under-employed one. To what extent do profits stay in Canada? What have been the costs to government? Is $1 per acre per year a large enough cost of holding leases to prevent hoarding and concentration? Is the $0.10 per ton royalty to the Alberta government, for example, high enough? Do the benefits of coal mining outweigh the costs? The reason these questions were not asked in other sections is that only coking coal is sold abroad in significant amounts. Most of the other types of coal produced in Canada are consumed by the domestic market.

In judging the coal industry in the Mountain region one should not be too hasty. The industry is only six years old and has grown considerably in that time. Although market performance seems to indicate a desire to maximize profits, a long history of government subvention payments and the apparent continuance of government subsidies makes one question the survival ability of some of the present (and perhaps future) operators without this aid. It seems unlikely that Canadian coking coal will be used in the eastern Canadian markets unless some form of government "encouragement" exists.[127] However, it is too early to judge this relatively new sector of the Canadian coal industry.

(4) Other Coal Mining Regions

Coal mining has taken place in various regions in Canada. However, only one operating mine exists outside of the regions outlined above. The Anvil Mining Corporation Limited mines some 20,000 to 25,000 tons of subbituminous

127 The Financial Post (June 8, 1974) reported that Stelco will buy 250,000 tons of metallurgical coal from western Canadian producers with the bulk of it coming from McIntyre Porcupine Mines Limited. However, the Federal government is encouraging such a transaction. Further, Stelco is seeking to gain an interest in the Smoky River mine; perhaps to ensure itself of a future coal supply, especially if it is thinking about taking part in the development of the Peace River iron ore deposits.

coal annually from its underground mine in the Yukon. This coal is used in conjunction with the company's lead-zinc operation.

Although many other potential mining areas exist in Canada, only two lignite deposits are likely to be mined in the near future. The Hat Creek and Onakawana deposits may be mined to provide fuel for thermal electric power generating plants. Coal found in northern Canada is unlikely to be mined on a large scale because of a small local market, large haulage distances to market, and a harsh climate and unstable environment. Other known Canadian deposits tend to be too small to facilitate a feasible mining operation. It should be pointed out, however, that much exploratory work remains to be done, both in the existing production areas and elsewhere, to determine the amount of recoverable coal which is available in Canada.

CHAPTER V

SUMMARY AND CONCLUSIONS

At the Sixth Commonwealth Mining and Metallurgical Congress in the mid-1950's it was stated that "the Canadian coal mining industry has had to produce coal economically in competition with imported coal and other fuels, and its record is not unimpressive."[128] Since that time the structure of the Canadian coal industry has been completely changed. No longer do the Maritime provinces dominate coal mining output as they have in the past. In this region government subsidies and finally government take-over and rationalization were necessary to prevent the collapse of the industry with its subsequent socio-economic problems. Although the Maritime coal industry will not disappear in the foreseeable future, its performance as a privately operated industry is rather difficult to assess, even from this vantage point in time.

The Mountain area producers of coking coal have also benefitted from government "interference" in the way of subventions, government manpower training programs,

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128 Burchell, D. G. et al. "Underground Coal Mining in Canada". Op. cit., p.542.

government assistance in the development of new towns, government sponsored railways, and other such direct, or indirect, subsidies. Although the coking coal producers are now firmly entrenched in the world coking coal market, it is questionable whether or not the output of this region would have been at the levels it is now without the government interference.

Only in the Plains area of Alberta and Saskatchewan and some parts of the Maritimes was government intervention in the coal industry not necessary. With the development of extra high voltage transmission lines, large and efficient strip mining operations were started in order to produce coal at costs which made it highly competitive with other fuels and methods of generating electricity. Although the coal was sold on a contract basis to the utility companies, many of which were government owned, this sector of the coal industry performed more like a competitive industry.

The markets for Canadian produced coal will continue to grow in the next 10 to 20 years. More coking coal producers will enter the industry to provide metallurgical coal to a growing world market. However, entry will be limited to existing coal producers (both coking coal and other) and to firms with ownership of, or options on, good quality coal reserves and the capital to develop these reserves. The demand for thermal coal by the power generating industry in western Canada and the Maritimes will also

increase but will be met almost entirely by increased output of the existing firms although B.C. Hydro may develop its lignite reserves at Hat Creek for power generating purposes. No coal producers are likely to enter the coal industry in order to supply coal for coal gasification plants located in Canada. High initial capital costs, the capital requirements of other energy projects, and uncertain gasification technology are just a few of the reasons why no coal gasification plants will be built in the near future (about 15 years). The same is true with regard to coal liquefaction.

Little coal is likely to be sold on the Ontario market by Canadian producers for two reasons. First, transportation costs from either the Maritimes or western Canada are very high although these can be expected to decline as a result of new technology. Second, long-term contracts and captive mines reinforce Ontario's reliance on the United States for most of its coal requirements. Any coal sold in eastern Canadian markets by Canadian producers will be to satisfy that demand which cannot be met by foreign producers. Exports of Canadian coal will increase substantially in the foreseeable future as Canadian coking coal producers expand their exports to Japan and also find markets for metallurgical coal in other countries. Exports to the United States may also increase, not because the U.S. cannot supply its own needs, but because it seeks to export its environmental problems.

Although the prospects for increased production of Canadian coal look good, one should not be too optimistic. New technology may increase the need for coal by increasing its uses or decreasing its costs per b.t.u., but it may also result in a decline in the demand for coal. Public awareness of how little the benefits of coal mining really are to the Canadian economy may impose a constraint on the expansion of output. Herfindahl and Kneese express this point best when they discuss the net benefits accruing to society as a result of a surface mining operation.

> In deciding whether the beauty of the (potential mining) areas is worth preserving, we must be careful to value correctly the contribution of the mineral deposit to the nation's product. This contribution is not measured by the market value of the ore produced, nor by the wages that are paid. The proper measure of what we (as a society) sacrifice by not mining the deposit is the profit or rent left over after deducting all expenses (including the competitive return on capital) from revenues.[129]

Therefore, the net benefits of coal mining tend to be negligible. The expansion of the industry will further be limited by stringent safety legislation for underground mines and land reclamation legislation, which can be expected as society values leisure and recreational activities higher.

The future of the coal industry in Canada seems to

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129 Herfindahl, Orris C. and Allen V. Kneese. Quality of the Environment: An Economic Approach to Some Problems in Using Land, Water, and Air. The John Hopkins Press, Baltimore, Maryland: 1965. p. 71.

be ensured but to expect extremely large increases in output over the next two decades seems unreasonable. As nuclear energy and other forms of energy come to the fore, they will act as a constraint on the future output of the industry as will other social and technological constraints. The resurgence of the coal industry in Canada will at the most be to serve energy demand in a transitional sense as new technology changes our need for coal. But the time span of this transition is unknown.

APPENDIX A

THE DEMAND FOR COAL

Introduction

The recent revival of interest in the coal industry is closely related to past events in the world energy scene and the writings contained in the various journals, especially those articles surrounding the works of the so-called doomsday prophets from MIT.[1] Because coal constitutes such a large percentage of the total fossil fuel reserves, it is of interest to consider present and past trends in its demand. In particular we would like to estimate a coal demand function which can hopefully be used for predicting the future demand for the vast reserves of coal. If the future demand is known with some degree of accuracy, future development of coal fields can be regulated in some manner instead of allowing the rather ad hoc exploitation which has characterized development in the past.

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1 I refer in particular to the Club of Rome and their funding of the Limits to Growth computer model of Dennis M. Meadows and the computer modelling team at MIT which uses the technique developed by J. Forrester.

The Model

Theory tells us that the demand for any final output is a function of the price of that output, the prices of all other commodities, and income. Hence, the demand for good i by consumer j is given as follows:

(1) $D_{ij} = D_{ij}(P_1, P_2, \ldots, P_n, Yj)$.

In order to isolate behavior in the ith market all other prices and income are assumed constant.

(2) $D_{ij} = D_{ij}\ (P_i)$.

The aggregate demand for commodity i is just the sum of the j consumer demands.

Similarly the demand for any input is a function of the price of the final output and the prices of all the inputs used in the production process. Hence the demand for input i by firm j is given by

(3) $D_{ij} = D_{ij}\ (r_1, r_2, \ldots, r_k, P_1, P_2, \ldots, P_m)$,

where the r's refer to the input prices used in producing the m commodities and the P's refer to the output prices of the m commodities which require input i.

Since data limitations prevent us from considering the general equilibrium cases of equations (1) and (3), it is well to consider only those parameters which enter directly into the demand function for the ith good. Rather than considering all incomes and prices constant, as was done in

equation (2), we consider all prices other than those of immediate substitutes to be constant. Hence the aggregate demand for output i, after summing over the total number of consumers and holding all prices other than those of substitutes constant, is

(4) $D_i = D_i\ (P_{s1}, P_{s2}, \ldots, P_{sn}, P_i, Y);$

where the S's refer to substitutes and the Y refers to per capita income.

Similarly all the input prices of those goods which do not compete with (are not substitute of) input i can be assumed constant.[2] Hence the aggregate demand for input i, after summing over the total number of firms and holding all input prices except those of substitutes constant, becomes

(5) $D_i = D_i\ (r_{s1}, r_{s2}, \ldots, r_{sk}, r_i, P_1, \ldots, P_m);$

where the S's refer to substitutes and the P's to the output prices of the m goods which use good i as an input.

Where a particular good is both an output and an input into some production processes, equations (4) and (5) can be combined to give the total demand for good i,

(6) $D_i = D_i\ (P_{s1}, \ldots, P_{sn}, P_i, r_{s1}, \ldots, r_{sk}, P_1, \ldots, P_m, Y)$

where P_i and r_i are the same. Since it is specified in

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2 Since we are dealing with the demand for coal we assume that the prices of complements are also constant.

relative prices this equation is homogeneous of degree zero.

The demand for coal can be stated in a functional form similar to that of equation (6); namely

(7) $D_c = f\ (P_c, P_1, \ldots, P_n, P_{n+1}, \ldots, P_{n+m})$.

In this form D_c refers to the demand for coal, P_c to the relative price of coal (relative to the n+m other goods), and the P's to the n substitutes for coal and the prices of the m commodities which require coal as an input. We do not make any distinction between the input and output substitutes for coal because the uses of coal are such that the same substitutes occur whether we consider coal as an input or as an output. Before specifying the exact form of the coal demand equations estimated in this appendix, it may be useful to keep the various markets for coal (as discussed in chapter 3) in mind.

Specification of the Equations and the Data

Since virtually no work has been done in the area of estimating the industrial or commercial demand for energy, we do not know our maintained hypothesis with certainty.[3]

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[3] Daniel Khazzoom makes an effort at trying to solve some of the problems related to the regression of energy demand equations in his book, An Econometric Model of the Demand for Energy in Canada 1960-1968. However, he concentrates mainly on disaggregate equations, considers mainly natural gas, and has a very short sample period.

Since we are ultimately interested in obtaining an aggregate demand function for coal, two countries, the United States and Canada, were chosen for consideration. For comparison a regression was run on a regional level. The region chosen was the Inner Plains area of Alberta because the market and producing area are the same and the coal type and quality are nearly the same throughout the region. Consumption by this region is entirely from the coal produced by the region. No imports into the area have occurred over the sample period (1947 to 1967).

The four aggregate functions which are specified had forms similar to equations (4), (5), and (6) above. In functional form they appear as follows:

(a) $D_1 = f_1\ (P_{c1}, P_F, P_{NG}, P_k, Y_{us})$,

(b) $D_2 = f_2\ (P_{c2}, P_F, P_{NG}, P_E)$,

(c) $D_3 = f_3\ (P_{c2}, P_F, P_{NG}, P_s, P_E)$, and

(d) $D_4 = f_4\ (P_c, P_{Ec}, P_s, P_G, P_O, Y_c)$.

The regional equation for Alberta had the following functional form:

(e) $D_5 = f_5\ (P_{cA}, P_{EA}, P_G, P_O, Y_c)$.[4]

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4 The notation has the following meaning:
D_1: demand for U.S. domestic coal as determined by retail deliveries.
D_2: demand for coal by electric power stations in the U.S.
D_3: demand for industrial coal in the U.S.

D_4: demand for coal in Canada.

D_5: demand for coal in Alberta.

P_{c1}: U.S. price of domestic bituminous coal.

P_{c2}: U.S. price of industrial bituminous coal.

P_c: value of Canadian coal f.o.b. the mine (weighted average).

P_{cA}: value of Albertan coal f.o.b. the mine (Inner Plains only -- a weighted average of the various mine values).

P_F: an average of P_{F1} and P_{F2} where

- P_{F1}: wholesale price of distillate fuel oil f. o.b. New York Harbor (#2 fuel), and
- P_{F2}: wholesale price of residual fuel oil f.o.b. Oklahoma (#6 fuel).

P_O: well-head price of oil in Canada.

P_k: U.S. price of kerosene.

P_{NG}: price of natural gas in the U.S.

P_G: well-head price of natural gas in Canada.

P_E: price of electricity in the U.S.

P_{Ec}: price of electricity in Canada.

P_{EA}: price of electricity in Alberta.

P_s: price of steel f.o.b. Pittsburgh

Y_{us}: per capita income in the United States.

Y_c: per capita income in Canada.

The first three functions are based on the United States economy whereas the last two are based on Canadian figures to a large degree.

The United States data were obtained from <u>The Survey of Current Business</u> published by the United States Department of Commerce. Canadian data were obtained from the Canadian Petroleum Association and Statistics Canada. Where Canadian observations were missing and the Canadian data which did exist followed closely the movements of the corresponding U.S. data, the U.S. data were used in determining the missing Canadian observations. The data were scaled so that it was possible to run a proper regression on the computer.[5]

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5 The final equations used data measured in the following terms:

D_1, D_2, D_3: millions of short tons

D_4, D_5: thousands of short tons

P_{c1}, P_{c2}, P_c, P_{cA}: \$/short ton

P_F, P_{F1}, P_k: \$/U.S. gallon

P_{F2}, P_O: \$/barrel

P_{NG}: \$/therm

P_G: ¢/1,000 cubic feet

P_E, P_{Ec}, P_{EA}: ¢/kwh.

P_s: \$/lb. (in the U.S. equations), \$/100 lb. (in the Canadian equations)

Y_{us}, Y_c: \$/person

Equation (a) is similar to an output demand function for coal whereas equations (b) and (c) can be regarded as input demand functions for coal. On the output side the prices of fuels competing with coal, namely, fuel oil (P_F), Kerosene (P_k), and natural gas (P_{NG}), and income per capita are considered to be the relevant parameters to include in the demand function, along with the price of coal itself. The price of electricity is not included because the demand for electricity usually gives rise to a demand for coal, oil, or natural gas (the fuels used in thermal electric power generating plants). Although prices for nuclear power and other forms of energy should have been included, they were not. The reasons for this are: (1) a lack of data and (2) the fact that such forms of energy are recent, or "new".

The input demand for coal depends on the price of the inputs (oil and natural gas, for example) which can be substituted for coal and on the output prices of the commodities which use coal as an input. Once again a lack of data prevents the use of input prices of other energy forms. In determining the demand for bituminous coal for electric power generating purposes in the U.S. (equation (b)), a variable "describing" the increase in hydro-generating capacity was added as an explanatory variable. When the results of the regression including this variable were compared with those of the regression without the variable,

it became apparent that the variable for hydro-capacity made little difference to the results obtained. The variable's coefficient was not significantly different from zero. Equation (c) is an input demand function for industrial coal in the United States. It neglects income as an explanatory variable because it is assumed that all industrial coal is used as an input. That 83 per cent of all coal is used by the steel and electric power generating industries seems to support this assumption.

Equations (d) and (e) are based on demand for coal in Canada and Alberta respectively. As such they include the prices of the inputs and outputs, which can be substituted for coal, and per capita income for Canada as a whole. It was assumed that per capita income movements in Alberta followed the national trends quite closely. Hence the national figure was used in the regional equation. Data on forms of energy other than those specified are also unavailable.

Each of the five functions, above, was specified as a polynomial function having the general form

$$Y_t = k\, X_{1t}^{b1}\, X_{2t}^{b2} \ldots X_{nt}^{bn}\, U_t.$$

The parameters of the resulting equations were then estimated using a log-linear regression analysis.

The Results

The results of the different regressions using ordinary least squares are given below. The term in brackets refers to the standard error and the "A" means that the antilog of the constant must be taken.

(a) $D_1 = A\ 24.01\ P_{cl}^{-1.04}\ P_F^{0.12}\ P_k^{1.35}\ P_{NG}^{-0.25}\ Y_{us}^{-1.91}$
(1.42) (0.37) (0.52) (0.80) (0.09) (0.10)

$R^2 = 0.9782$

(b) $D_2 = A\ 7.50\ P_{c2}^{-0.41}\ P_F^{0.014}\ P_{NG}^{-0.10}\ P_E^{-2.31}$
(0.95) (0.21) (0.23) (0.06) (0.14)

$R^2 = 0.9803$

(c) $D_3 = A\ 10.60\ P_{c2}^{-0.62}\ P_F^{0.75} P_{NG}^{-0.097}\ P_s^{0.31}\ P_E^{-1.20}$
(0.80) (0.14) (0.15) (0.039) (0.17) (0.15)

$R^2 = 0.9730$

(d) $D_4 = A\ 1.035\ P_c^{-0.11}\ P_{Ec}^{-0.31}\ P_G^{-0.001}\ P_O^{0.68}\ Y_c^{1.28}$
(1.435) (0.16) (0.34) (0.25) (0.016) (0.21)

$R^2 = 0.9513$

(e) $D_5 = A\ 11.38\ P_{cA}^{-2.87}\ P_{EA}^{-0.82}\ P_G^{0.03}\ P_O^{4.48}\ Y_c^{-0.68}$
(15.19) (0.57) (1.31) (0.08) (1.54) (2.08)

$R^2 = 0.9304$

A linear functional form was also used but the results were similar to those given above. An alternate estimating technique, the Cochrane-Orcutt iteration technique, was also used but the results differed only slightly from those given by the ordinary least squares method. Much of

the demand for coal tends to be a captive demand rather than a free demand. Almost three-quarters of the coal sold in Canada and much of that sold in the United States is sold on a contractual basis to the electric utilities and the steel companies. Prices are thus bound by these contracts and this might introduce an autoregressive element into the analysis. However, it seems that if autoregression is present it is rather small as indicated by the little difference between the alternate estimating techniques.

Multicollinearity is always a problem in any estimation procedure. However, it is a problem of degree only. The correlation tables for the log-linear regressions (Tables A1 through A5) seem to indicate that the degree of multicollinearity is higher for the Canadian data than it is for the U.S. cases. A "high degree of multicollinearity is simply a feature of the sample that contributes to the unreliability of the estimated coefficients, but has no relevance for the conclusions drawn as a result of this unreliability."[6] Little can be done to correct this problem.

Misspecification was a most troublesome problem. Although little can be done from a statistical point of view because misspecification occurs at the theoretical level,

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6 Kmenta, Jan. Elements of Econometrics. The Macmillan Company, New York: 1971. p. 391.

CORRELATION MATRICES FOR THE LOG-LINEAR REGRESSIONS

TABLE A1

U.S. Domestic Demand -- Equation (a)

	D_1	P_{c1}	P_F	P_k	P_{NG}	Y_{us}
D_1	1.000	-.292	.255	.440	.320	-.970
P_{c1}		1.000	.406	.086	-.692	.256
P_F			1.000	.732	-.303	-.184
P_k				1.000	-.147	-.316
P_{NG}					1.000	-.405
Y_{us}						1.000

TABLE A2

U.S. Electrical Demand -- Equation (b)

	D_2	P_{c2}	P_F	P_{NG}	P_E
D_2	1.000	.614	-.169	-.457	-.987
P_{c2}		1.000	.345	-.878	-.663
P_F			1.000	-.278	.129
P_{NG}				1.000	.474
P_E					1.000

TABLE A3

U.S. Industrial Demand -- Equation (c)

	D_3	P_{c2}	P_F	P_{NG}	P_s	P_E
D_3	1.000	.565	-.030	-.417	.891	-.955
P_{c2}		1.000	.345	-.878	.651	-.663
$P_F{}^4$			1.000	-.278	-.202	.130
P_{NG}				1.000	-.502	.474
P_s					1.000	-.930
P_E						1.000

TABLE A4

Demand for Coal in Canada -- Equation (d)

	D_4	P_c	P_{Ec}	P_s	P_G	P_O	Y_c
D_4	1.000	-.838	-.873	.726	.253	-.716	.928
P_c		1.000	.830	-.571	-.017	.733	-.816
P_{Ec}			1.000	-.872	-.350	.913	-.955
P_s				1.000	.274	-.828	.874
P_G					1.000	-.263	.291
P_o						1.000	-.892
Y_c							1.000

TABLE A5

Demand for coal in Alberta -- Equation (e)

	D_5	P_{cA}	P_{EA}	P_G	P_O	Y_c
D_5	1.000	-.922	-.798	.256	-.628	.852
P_{cA}		1.000	.943	-.274	.844	-.967
P_{EA}			1.000	-.281	.946	-.970
P_G				1.000	-.263	.291
P_O					1.000	-.892
Y_c						1.000

an attempt was made to arrive at an equation with the proper parameters by regressing a number of differently specified equations. It appears that the log-linear regression of equation (c) (the industrial demand for coal in the U.S.) gives the best results from a significance point of view. Only in this equation are all the coefficients significant with the value of R^2 being high as well. (The results for Alberta (equation (e)) were poor using these criteria and hence could not be used for comparison purposes.) Even though the misspecification problem has not been eliminated, the results for equation (c) provide a good indicator of what parameters to include.

One of the most pressing problems of estimating demand equations is the problem of identification. Are we estimating a demand equation or are we estimating the movement of demand along a supply curve, i.e. the supply curve itself? Statistical criteria cannot determine whether an equation is identified or not. Hence we cannot pursue this issue further.

Interpretation and Explanation

Theory tells us that for a normal good demand varies inversely with the price of that good and directly with the price of substitutes for that good. In other words, if the price of the substitutes of a particular commodity (whether an input or an output) goes up, then the demand for the commodity increases. Furthermore, as income increases more of the commodity (as well as other goods one normally buys) would be demanded. But is coal a normal good? The analysis seems to indicate that it is not!

Earlier we saw that there was a gradual shift from coal to other types of fuel between the years 1947 and 1967 regardless of what prices were doing. It seems that coal was too inconvenient to use as a fuel for space heating. In addition, as per capita income rose, people demanded a cleaner environment, which meant that less coal (the most air-polluting fuel) would be burned. Hence one would expect

the elasticity of demand for coal with respect to income to be negative. Further, it is too inefficient as well as inconvenient to use coal as a fuel for steam locomotives and space heating. This inefficiency reason, along with the inconvenience one, may result in negative coefficients for the price of coal substitutes.

The analysis supports our contention that demand varies inversely with the price of the good. Hence coal is not a Giffen good. In equation (a) the domestic demand for coal in the United States was found to vary inversely with income as we expect from our previous discussion. Thus coal is an inferior good from the point of view of the final domestic coal consumer; the reason probably being its inconvenience. Hence coal can be considered an inferior good in this sense. But if the demand for coal is a derived demand it is possible that its demand increases as income increases, in which case coal is a normal good. It seems reasonable, and the results for Canada and Alberta support this, that as income increases the demand for electricity and steel increases thereby increasing the demand for coal.

When we consider the input demand for coal we find that as the prices of the outputs (in which coal is used as an input) increase the amount of coal demanded may increase or decrease. This is a very perplexing problem if one considers what theory says. If we assume that the costs of production (in this case of electricity and steel) do not

increase, theory tells us that the price increases are due to demand increases. These demand increases then lead to an increase in the demand for inputs (coal). Is there a misspecification problem?

The third log-linear equation, that giving the demand for industrial coal in the United States (D_3), offers some hope for an explanation. (This equation was the one considered to be the best.) The coefficients for the price of steel are positive indicating a greater demand for coal as the price (and hence the demand) of steel increases. An increase in the price of (demand for) electricity is shown by our analysis to decrease the demand for coal. The reason for this is the fact that there has been a shift to other fuels during two-thirds of the years of our sample data and this shift occurred regardless of relative prices. Both new investment resulting from an increased demand for electricity and replacement investment was in non-coal-using thermal electric power plants during most of our sample period. The same cannot be said of steel production as there are no real substitutes for coking coal.

The analysis also indicates that in some instances the demand for coal decreased as the prices of substitute fuels increased contrary to what we would expect. Two forces acted on coal demand whenever prices of competing fuels increased. First, the price effect caused more coal to be demanded and second, the "convenience effect" always

worked to reduce coal demand. Whenever the convenience effect (which also includes pollution externalities) outweighed the price effect, which was quite often over our sample period, it resulted in the illusion that less coal would be demanded whenever the prices of coal substitutes went up.

Conclusion

At the beginning of this paper it was stated that the reason for wanting to look at a demand for coal function was the fact that such a function can be used for prediction. In light of the recent upheavals in the energy area it now seems unreasonable to attempt prediction, not only of future coal demand but also of other energy demands, based on econometric results of the past. The energy markets are too unstable to permit statistically accurate prediction.

We have seen that there was a gradual decline in coal demand as new fuels came onto the market replacing the traditional market, railways and space heating, previously held by coal. The recent increases in demand have resulted from increased energy and steel output needs. Coal has found its place as a dominant fuel for the production of electricity since extra high voltage transmission lines have reduced the need to transport coal. But the environmental (land, air, and water) damage which the extraction and burning of coal creates may be a factor in keeping the demand for coal

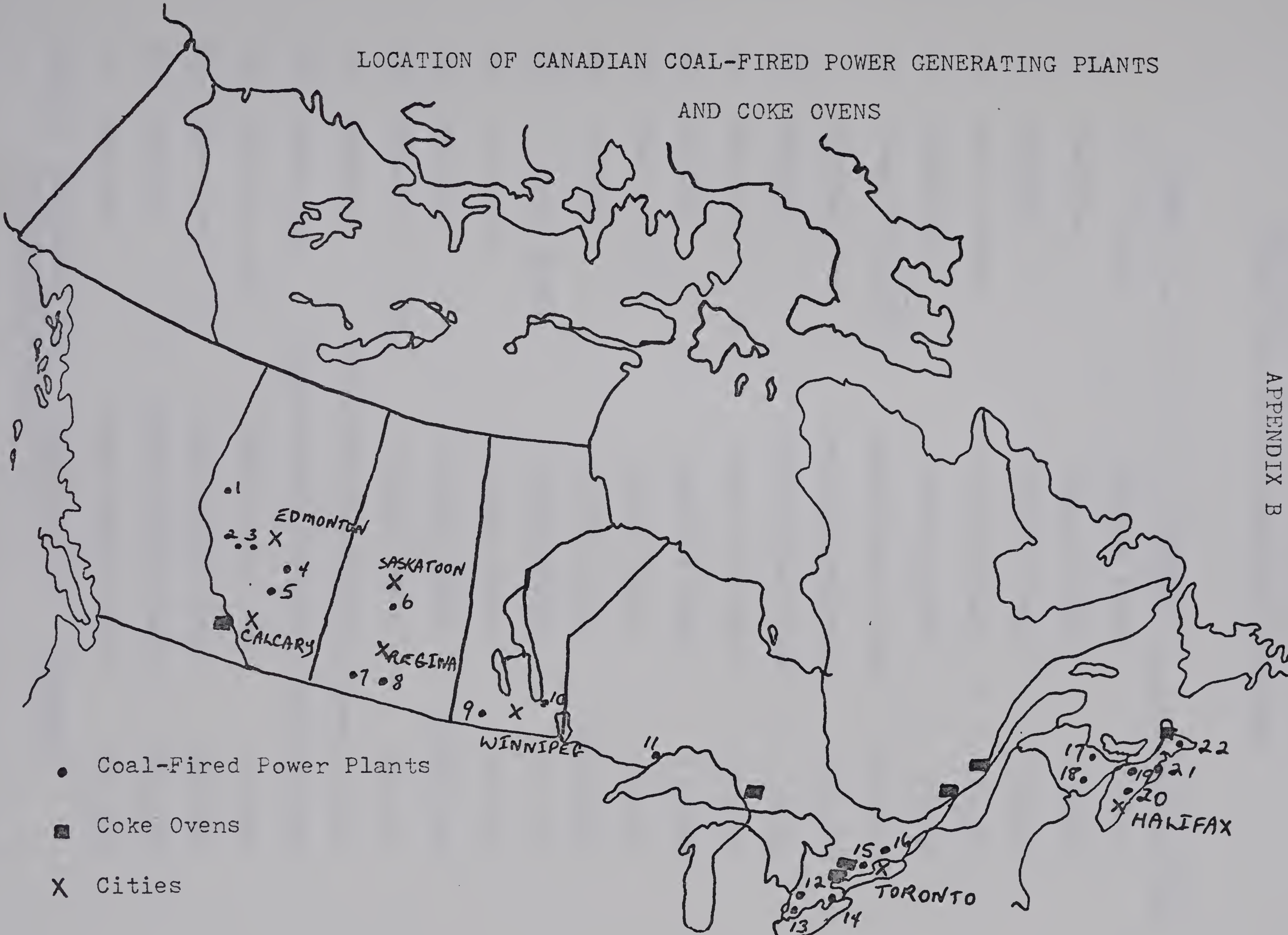
in check. Developments in the nuclear field and the solar energy field, and the possibility of harnessing the tides will have a profound effect on coal demand as will new discoveries of oil and gas, coal gasification, and other technological changes. All these and other energy events, and their uncertainty, makes it difficult for one to predict future demand for coal by resorting to past events.

However, in order not to disillusion those attempting to find energy demand functions, it should be pointed out that much econometric and other work still awaits resource and energy economists. The present is a time of energy confusion which will be sorted out over the next few years. Once stability is regained, prediction will again become fruitful.

APPENDIX B

LOCATION OF CANADIAN COAL-FIRED POWER GENERATING PLANTS

AND COKE OVENS



• Coal-Fired Power Plants

■ Coke Ovens

X Cities

Coal-Fired Power Generating Stations

	Name	Company	Capacity(KW)
1.	H.R. Milner	Alberta Power	150,000
2.	Sundance	Calgary Power	300,000
3.	Wabamun	Calgary Power	582,000
4.	Battle River	Alberta Power	216,000
5.	Drumheller	Alberta Power	17,500
6.	Queen Elizabeth	Saskatchewan Power	241,000
7.	Boundary Dam	Saskatchewan Power	432,000
8.	Estevan	Saskatchewan Power	70,000
9.	Brandon	Manitoba Hydro	237,000
10.	Selkirk	Manitoba Hydro	155,800
11.	Thunder Bay	Ontario Hydro	128,300
12.	Lambton	Ontario Hydro	2,030,000
13.	J. Clark Keith	Ontario Hydro	271,500
14.	Nanticoke	Ontario Hydro	500,000
15.	Lakeview	Ontario Hydro	2,430,000
16.	Richard L. Hearn	Ontario Hydro	800,00
17.	Chatham	New Brunswick Electric Power	32,500
18.	Grand Lake	New Brunswick Electric Power	85,000
19.	Harrison Lake	Nova Scotia Power	26,500
20.	Lower Water St.	Nova Scotia Power	167,500
21.	Trenton	Nova Scotia Power	210,000
22.	Seaboard	Nova Scotia Power	108,000

Source: Chrismas, L.P. "Coal and Coke", Canadian Minerals Yearbook, 1972.

APPENDIX C

CALCULATION OF COAL REQUIREMENTS BY CANADIAN POWER PLANTS IN 1977.

In order to calculate the quantity of coal which a particular generating station requires use of the following is made:

Coal Requirement = Generating Capacity X Load Factor X
Heat Rate X Heat Content.

The values of the variables are found in the text and can be used to calculate the coal requirements in 1977 by province and rank of coal.

<u>Alberta</u>

Coal Required = 2,555,000 KWH X 4,500 HR X 10,500 Btu/KW
X lb/8,500 Btu X ton/2,000 lb.
= 7,100,000 tons

Subbituminous coal requirements in 1977 = 7,100,000 tons.

<u>Saskatchewan</u>

Coal Required = 1,193,000 KWH X lb/7,000 Btu
X 23,625 Btu. ton/lb. KWH
= 4,026,000 tons.

<u>Manitoba</u>

Coal Required = 393,000 KWH X lb/7,000 Btu X 23, 625 Btu.ton/
lb. KWH
= 1,326,000 tons

Lignite requirements in 1977 = 5,353,000 tons.*

Ontario

Coal Required = 9,660,000 KWH X lb/11,500 Btu

X 23,625 Btu. ton/lb. KWH

= 19,845,000 tons.

New Brunswick

Coal Required = 117,000 KWH. X lb/11,500 Btu

X 23,625 Btu. ton/lb. KWH

= 240,000 tons.

Nova Scotia

Coal Required = 512,000 KWH X lb/11,500 Btu

X 23,625 Btu. ton/lb. KWH

= 1,050,000 tons.

Bituminous coal requirements in 1977 = 21,134,000 tons.*

Total coal requirements for electric power generating purposes in Canada in 1977 = 33,587,000 tons.

The actual amount of coal required by the Canadian electric power generating industry would differ from these estimates. Errors in the actual load factor which varies from area to area could result in estimates which are lower or higher than those above. It was assumed that all

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* Figures do not add due to rounding.

of the Ontario power plants wold burn bituminous coal. However, significant changes in prices and sources of supply (Western Canada vis-a-vis the United States) could result in last minute changes in the type of coal which the generating stations could burn. Further, changes in plans could result in more or less coal-fired electric power generating units being built. These and other sources of error could result in a variation of our estimate by about 20 per cent or more.

APPENDIX D

SOURCES OF WORLD COKING COAL

The table on the following page gives some indication of the production and use of coking coal by various countries and gives an indication of Canada's competitiveness in the world metallurgical coal market. Note that the United States does not need to import any coking coal whereas Japan is dependent on imports. The trend in the original EEC (European Economic Community) countries is towards increasing imports.

Major Sources of Coal

United States, EEC Countries and Japan

(Percent of Total)

	1972 United States	1971 Japan Coking Coal	1969 Coal for Coke Plants -- EEC*
United States	100.0%	31.6%	6.0%
Canada	-	11.3	-
EEC*	-	-	88.5
Other Europe	-	2.0	3.2
Latin America	-	-	-
Africa	-	-	0.2
Australia	-	27.3	0.3
Japan	-	23.7	-
Other Asia	-	-	-
U.S.S.R.	-	4.0	1.8
Other	-	0.1	-
	100.0	100.0	100.0

* Original 6 countries

Source: American Iron and Steel Institute. Steel Industry Economics and Federal Income Tax Policy. February, 1974. P. 53.

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